In this issue . . . .

Survey of Product Developments—During August the editors mailed 2,000 questionnaires to a selected group of subscribers made up of chief engineers and designers active in the leading metal-working plants in the United States. 173 questions concerning their activities in product development were asked. During September, 597 questionnaires were received. The complete tabulation and analysis of this important project occupy 17 pages of this issue Page 434

Alloys—W. D. Staley reviews the circumstances that led to the development of Illium and reveals the physical characteristics of this corrosion-resisting alloy Page 456

Cam Mechanisms—Professor Hall concludes his authoritative anaylsis on the inertia effects in different types of cams Page 458

Gluing Mechanisms—Two more pages for the engineer's data book showing designs of mechanisms for applying glue for incorporation into the design of packaging machines and the like Page 454

Product Developments—Among other engineering achievements will be found the largest diesel in the world, new uses for magnesium alloys, a microphone molded out of a phenolic resinoid, and "gas bottles" that take the place of weighted accumulators in a hydraulic system Page 451

Springs—Victor Tatarinoff of Czechoslovakia contributes two reference book sheets to assist in calculations for round- and rectagular-wire helical springs Page 471

Coming issues . .

The fourth installment of "Motors and Controls" will deal with solenoids and torque motors

Henry Simon will describe the design of a massive measuring instrument which is almost unbelievably precise

E. C. Shanks will follow Professor Hall's notable series on inertia in cam mechanisms with an article describing methods for laying out consecutive tangential arcs

PRODUCT ENGINEERING

Devoted to the Interests of Engineers and Executives Responsible for Product Design and Development

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November, 1932

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Published monthly. $2 per year. 25 cents per copy. Central and South America, $3.00. Canada, $3.50, including duty. Foreign, $4.00 U. S. currency, or 20 shillings. Entered as second-class matter, January 17, 1930, at the Post Office at New York, N. Y., under the Act of March 3, 1879. Printed in U. S. A. Cable address: "McGraw-Hill, N. Y." Member A.B.C.

McGRAW-HILL PUBLISHING COMPANY, INC., 330 WEST 42d STREET, NEW YORK, N. Y.

Branch offices: 520 North Michigan Ave., Chicago; 883 Mission St., San Francisco; Aldwych House, Aldwych, London, W. C. 2; Washington; Philadelphia; Cleveland; Detroit; St. Louis; Boston; Greenville, S. C.; Los Angeles. James H. McGraw, Chairman of the Board; Malcolm Muir, President; James H. McGraw, Jr., Vice-President and Treasurer; Mason Britton, Vice-President; Edgar Kobak, Vice-President; H. C. Parmelee, Vice-President and Editorial Director; Harold W. McGraw, Vice-President; C. H. Thompson, Secretary.

There is no substitute for product development

. . . for any manufacturer who seriously wants to make money

Business in America is never static. No manufacturer's markets are "his, to have and to hold." Other keen-witted manufacturers are always sharpshooting at his customers, —lying awake nights thinking of new engineering and sales ideas. Leaders keep ahead of their competitors by continual product development.

Granting due credit to salesmanship and merchandising science, the fact remains that in the long run the product either sells on its merit, or "flops." Wise manufacturers know that active product development is the most practical thought that they can give to tomorrow. They watch the editorial and advertising pages of Product Engineering for designs, parts, and materials that they can incorporate for the betterment of their own products.

PRODUCT ENGINEERING

PRODUCT ENGINEERING

MCGRAW-HILL PUBLISHING CO., INC. VOLUME THREE, NUMBER ELEVEN

NOVEMBER, 1932

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What Is Going On In

PRODUCT DEVELOPMENT

HAS the big day of new products ended? Must I as a product engineer find some other means of self-expression and of making a living? Will people buy new things or must they try to be satisfied with the old ones until worn out?

These are questions that have been worrying product engineers for many months, and with reason. Some of them have seen engineering staffs cut to the bone, good engineers turned out to hunt a job after years of experience in their special fields. They have suffered salary cuts and they have taken vacations without pay.

Is their morale shaken? Are they slowing down because of the uncertainty of the future? Just what are they doing?

Engineers want the answers to both sets of questions. So do a lot of other people.

To get these answers *Product Engineering* has gone to the field to find out. Questionnaires supplied the bulk of the information but the conclusions have been checked against those drawn from field visits by *Product Engineering* editors and by the editors of twenty other McGraw-Hill papers.

Summaries of the responses are published on succeeding pages; a general one, and twelve specific ones for the major divisions of the field. They are illuminating. Every reader of *Product Engineering* will get from them both inspiration and information. Inspiration, because product development is going forward as strongly as ever in most of the fields. The big companies, it is true, have shortened forces, but the smaller ones report hardly any change. Information, because the trends indicated in your own field are vitally important from the competitive viewpoint, and because the trends in other fields offer suggestions that you may seize and develop for your own.

The editors have always held that product development is vital to the continuation and growth of American industry. That is unquestionably true of the domestic market, and it will be equally true of the foreign market now that manufacturers and engineers in other industrial countries have had three years to catch up with the best we have been able to put on the market. We must have new things if we are to compete abroad, because the European manufacturer can usually undersell us where we are without tariff protection.

A TURN has come in the long side of business and industry from frantic energy in 1929 to gloomy inactivity in 1932. Whether it will be followed by a steady climb to general prosperity and re-employment remains to be seen. The obstacles are many but the spirit of the country has changed from fear approaching desperation to a grim but hopeful determination to rebuild. The organization of the Robertson Committee for Industrial Rehabilitation is evidence thereof.

Rehabilitation depends largely on the merit of the new products of all kinds which are offered to replace the worn out and the obsolete units in home or factory. As our survey shows, the product engineer is doing his part of this work now. Thanks to his efforts the new machinery, products, devices will be at hand when needed.

K. H. Condit

Editor

Current Activity in

PRODUCT DEVELOPMENT

Complete summaries, critical analyses and authoritative comments on the results of a nation-wide survey covering the entire metal-products industry, segregated into 12 fields to reveal present and contemplated degree of activity, design factors being emphasized, and latest trends as exhibited by recent and contemplated adoptions of

NEW MATERIALS—TYPES OF CONSTRUCTION
PURCHASED PARTS—SURFACE FINISHES

For the purpose of obtaining reliable information on the status and trends in product development activities, 2,100 questionnaires were mailed to a selected list of readers of *Product Engineering,* representing chief engineers, research and development engineers, and chief draftsmen in all lines of metal-products manufacturing. To make certain that the results of the investigation would not reflect local conditions in any one section of the country, representative companies from coast to coast were selected.

The response was unexpectedly gratifying. Exactly 597 replies were received. These were carefully classified and studied, and those which contained insufficient information or were duplicates were discarded. The 430 informative replies were then segregated into eleven classified groups and one group containing companies whose products did not fall into any one of the eleven classifications.

Some idea of the scope of the questions asked, and the detailed information requested, is shown by the summaries on the following pages. On the reverse side of the questionnaire were listed 53 items of parts and materials which were to be checked to indicate those that are being used in the present product, those that have recently been adopted, and those whose adoption is being contemplated. Although most of the questionnaires gave checks against items under the first heading, less than one-half gave any information regarding recently adopted or the contemplated adoption of new parts and materials. This was to be expected as many manufacturers feel loath to divulge any information regarding contemplated changes in their product. This accounts for the fact that except in one instance no attempt was made to tabulate in this summary the number of companies that have recently adopted or are contemplating the adoption of certain new parts and materials.

Undoubtedly, many will be surprised at some of the information given in this analysis. Yet, in practically every instance, the statements are logical and conform to general business conditions.

It is not the purpose of this summary to forecast what the survey might indicate relative to prospective activities in the various branches of industry. Other than brief comments by men closely in touch with the different industries, the presentations on the following pages are confined to a summary and critical analysis of the facts as established by this nation-wide investigation.

With reference to the eleven major groups that were selected, a strict division could not be made in every instance. The wide diversity of activities of some manufacturers made it necessary to put them in that group which represented the major portion of their activity. Also, by a careful selection of the groups, it was possible to minimize the overlap. Thus, mining equipment and construction machinery is included in one classification because most of the manufacturers catering to the one class also manufacture for the other group. However, the limited extent of any overlapping can have no appreciable effect upon the final results as summarized. Furthermore, in those instances where specific products or a specific line of products in a group showed individual trends markedly different from the other members of the group, special mention is made and the detailed information and data presented.

With reference to the lists of items recently adopted or contemplated, it must be remembered that only those parts and materials that are receiving an outstandingly large amount of attention were mentioned. In every case there were scattered instances relative to the adoption of parts or materials, but to have included every item checked would have resulted in excessively long lists that would have no real significance with reference to some of the items. Also, it must be remembered that the omission of such familiar items as ball or roller bearings, die-castings and molded products in some of the groups signifies that these items have become so well established that mention of their fur-

ther adoption would be superfluous.

In addition to the information obtained from the questionnaires, many personal visits were made to manufacturing plants by members of the editorial staff of *Product Engineering* and by those of 20 other associated McGraw-Hill publications. But in order to eliminate the possibility of any hearsay evidence, no verbal information resulting from such visits is included in this summary. Such information did serve, however, to corroborate the accuracy of the information that was given on the returned questionnaires.

Automotive Industries

For the past ten years the automotive industry has been the leader in product development, yet opportunities for further product development are as great as ever. Better shock-absorbing devices, lighter weight, more power and improved appearance are being stressed continuously. Many new materials are being adopted, while automatic gear shifting and the new low-pressure tires will require complete redesign of steering mechanism and chassis.

—G. E. QUISENBERRY

Editor, American Automobile, Overseas Edition

Manufacturers of automobile passenger cars and trucks, airplanes, automotive and marine engines, automobile parts and accessories, and service station equipment are included in this group of 71 manufacturers. For the whole of this industry, the average number of men employed in design, research and product development, during the successive six months' periods beginning with January 1931, is shown by the following tabulation:

NUMBER OF MEN EMPLOYED

1931, first half	1,522
1931, second half	1,592
1932, first half	1,333
Present time	1,107

Taking the industry as a whole, there has been a decrease of 27 per cent in the number of engineers employed. However, a consideration of the different divisions of this group reveals some extremely interesting comparisons. The increase in personnel during the second half of 1931 over the first half of that year undoubtedly reflects the increased activity necessitated by getting out the designs for the new models. Also, the severe drop since the first half of the present year can possibly be at least partially accounted for by the fact that the usual increased fall activities had not become effective at the time this information was obtained.

Considering the various divisions of this group, extremely interesting facts are brought to light. For example, the 32 parts and accessories manufacturers show a drop of only 16 per cent in the number of engineers employed during the period from 1931 to date. For the period from the second half of 1931 to date, inclusive, this same division shows a loss of less than 9½ per cent in the number of engineers employed, while since the first of the year the number of men has remained practically constant. In view of the unquestioned drop in the production of new automobiles, this surprising situation might possibly be explained by the many antiquated cars now on the road which require a constantly increasing amount of new parts. This assumption also seems to be borne out by the fact that the manufacturers of service-station and garage equipment have decreased their engineering personnel less than 4 per cent during the period from July 1931, to date. Individual manufacturers in this line of equipment have, in numerous instances, shown an actual increase in the number of product engineers employed and more than one-half of the companies about which reports were received are experiencing an activity equal to or greater than that during any period since January 1931.

With further reference to the manufacturers of service-station equipment, another factor accounting for the relatively high activity is the expansion in automobile service-station equipment. Thus, with automobile filling stations going into the business of selling tires and accessories, it has opened the way to numerous service station equipment companies to add specially designed display cases, cabinets and similar fixtures to their lines of products.

Again taking the industry as a whole, the following table gives the relative product development activities for the various periods:

RELATIVE DEVELOPMENT ACTIVITY

	Companies
Activity greater than 1931	25
Activity greater than 1932, first half	20
Activity less than 1931	30
Activity less than 1932, first half	26
Constant activity throughout above period	6
Future Activity	
No change contemplated	49
Increased product development programs	20

It is interesting to note that about

Courtesy Standard Oil Company of New Jersey

Between the gasoline pumps can be seen the "Island Store" for displaying motorists' supplies, a late innovation brought about by filling stations expanding their retailing activities. Such equipment must be pleasing in both form and color

one-third of the manufacturers of automobile accessories and service-station equipment are contemplating increased activities in the immediate future, mainly through the development of new products in both the present and new lines.

General trends in the product development activity in this industry are indicated in the following table:

GENERAL CHARACTER OF PRODUCT DEVELOPMENT

	Companies
New products in present line	60
New products in new line	15
Designs for higher price class	16
Designs for lower price class	32
Redesigns chiefly for lower manufacturing costs	32
Designs to provide a greater number of styles or sizes	22
Redesigns for simplification of product	32
Designs to widen the range of use of equipment	18

Again referring to the various divisions in this group of manufacturers, it is interesting to note that none of the automobile companies are developing products in a new line whereas the airplane, service-station equipment, and accessories manufacturers are all putting forth effort toward extending their lines of products. Relative to the question of higher or lower price class, price evidently is not a consideration in the automotive industries, according to the reports submitted, whereas more manufacturers of service-station equipment are aiming at a higher class of goods than are developing products for the lower price class. Undoubtedly this last item can be largely explained by the fact that the modern up-to-date filling station demands quality equipment in conformity to its attractive architecture. On the other hand, accessories manufacturers are almost unanimously aiming at lower price goods, possibly to meet the pocketbooks of the impoverished automobile owners who are clinging to their ancient vehicles.

On account of the wide diversity of products represented in this group, a tabulation of the design factors that are being emphasized would be rather meaningless. However, considering the separate divisions in this group, airplane manufacturers are bending their efforts toward higher speeds, larger and heavier machines, improved lubrication, improved lock washers and locking devices, more easily replaceable units, and, leading the list, corrosion-resisting materials.

As is to be expected, automobile manufacturers are paying greatest attention to the form of their product, with higher speeds ranking second in importance. Truck manufacturers are emphasizing larger and heavier units. Other important items are the minimizing of vibration, improved lubrication, more easily replaceable units, improved surface finishes and color schemes, and materials adopted to improve the appearance.

Regarding the attention that is being given to service-station equipment, these companies are reported as putting the greatest emphasis on surface finish and form, with materials for corrosion-resistance being the second most important item. Referring to filling station pumps in particular, gears, springs and electrical controls are receiving most attention.

In the order of their importance, automobile engine and accessories manufacturers are emphasizing corrosion-resisting material, improved lubrication, surface finish, materials adopted for improved appearance, and materials or devices to minimize the effects of vibration.

In view of the above, it is not surprising that the questionnaires indicate a great number of instances of the adoption or contemplated adoption of corrosion-resisting materials, such as aluminum and its alloys, copper-nickel alloys and stainless steels. In the service-station equipment division of this group, corrosion-resisting materials, porcelain-enamel finishes, lacquers and plated surfaces are receiving greatest attention. Molded plastics are coming into more general use and Thiokol is now being used for the valves and packings of gasoline filling station pumps.

Welded construction, drawn or extruded shapes, are evidently receiving exceptional attention, while in the design of steering gears for passenger and commercial vehicles, pumps and controls for hydraulic operation are being considered.

Some of the particularly interesting items whose adoption is being contemplated by various manufacturers include: magnesium alloys, needle bearings, silent chains, stainless steels, molded parts, copper-nickel alloys, die-castings, and various platings. Numerous other items mentioned include; rubber, fibre, cork, molded composition gears, celluloid, lubricating devices, and flexible shafting.

Electrical Equipment for the Home

The electrical appliance business has always depended on the continuous development of new products and the refinement of old ones to give added talking points and value for justifying price increases or maintaining profitable price levels. The situation pictured here is characteristic of this industry, and shows the confidently expected improvement both in gross business and in unit prices.

—L. E. MOFFATT
Editor, Electrical Merchandising

This group is represented by 42 manufacturers engaged in the production of oil-burners, stoves, furnaces, electric refrigerators, clothes washing machines, dish washers, domestic pumps, vacuum sweepers, radios, and similar equipment. Their relative activity is shown by the following tabulation:

RELATIVE DEVELOPMENT ACTIVITY

	Companies
Activity greater than 1931	16
Activity greater than 1932, first half	16
Activity less than 1931	14
Activity less than 1932, first half	11
Constant activity throughout above periods	3
Future Activity	
No change contemplated	23
Increased product development programs	6

A better picture of their product development activities throughout the period beginning with 1931 can be obtained by considering the number of men engaged in research, design and product development.

NUMBER OF MEN EMPLOYED

1931, first half	523
1931, second half	492
1932, first half	483
Present time	420

For all the companies represented, there has been a drop of 20 per cent in the number of men thus engaged. However, if the companies engaged in the manufacture of radios be excluded from this count, there has been a drop of only 13 per cent. Of greater significance is the fact that if, in addition, the two largest manu-

facturers of home equipment be omitted from the picture, the number of men now employed in the designing and development of home equipment is 2 per cent greater than the number of men thus engaged in the first half of 1931.

Again considering all of the companies included in this group, 12 report the same number of men now engaged as were employed in the first half of 1931, while eight companies report an average increase of 42 per cent in the number now engaged in product development activities as compared to the first half of 1931. It is also extremely significant that only one of these eight companies has an engineering personnel greater than 12 men. This seems to indicate that at least in this group it is the small companies that are leading the way to increased product development activities.

The general character of the product development program is shown by the following table:

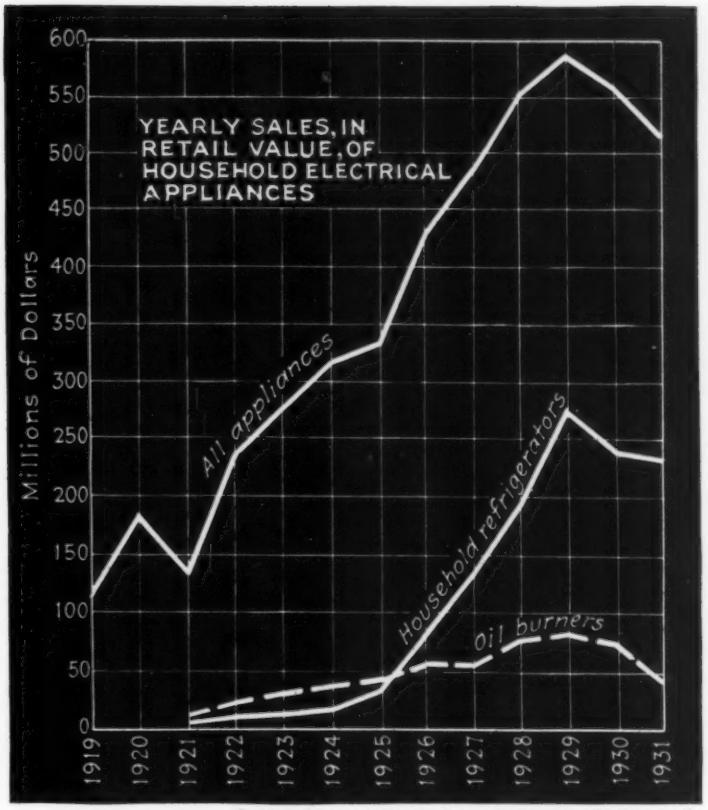
GENERAL CHARACTER OF PRODUCT DEVELOPMENT

	Companies
New products in present line	37
New products in new line	11
Designs for higher price class	7
Designs for lower price class	25
Redesigns chiefly for lower manufacturing costs	18
Designs to provide a greater number of styles or sizes	20
Designs to widen the range of use of the equipment	13

Product improvements that are being aimed at by the development and engineering departments of these companies are shown in the following tabulation which indicates the specific manner in which the product development program aims to increase the sales value of the product:

DESIGN FACTORS EMPHASIZED

	Companies
Higher speeds of operation	6
More automatic operation	12
Greater precision in use	13
Less power consumption	14
Improved gearing	3
Better electrical control	16
Devices or materials to minimize vibration	12
Improved lubrication	10
Adoption of corrosion-resisting materials	22
Improved lock washers and locking devices	9
Closer manufacturing tolerances	12
More easily replaceable units	20
Restyling for new form	20
Better surface finish	22
Improved color schemes	7
Materials adopted for improved appearance	20



Courtesy Electrical Merchandising, Refrigerator Division of the N.E.M.A., and the American Oil Burner Association

In number of units sold, this industry has fared better than as shown by these curves, particularly as to refrigerators and oil burners. But of greatest significance is the fact that there has been practically no decrease in engineering activities

The particular means by which the product development aims are to be accomplished is strikingly shown by the new parts and materials and new methods of construction that have been adopted recently by some of the companies. Apparently, as indicated by the reports, the necessity for lower-priced goods has brought about a wider use of welded construction, which has naturally also resulted in adoption of rolled, drawn, or extruded shapes. If low cost is the slogan, it must be that the many manufacturers who are increasing the use of alloy steels have found them to be economical.

Of greater interest are the parts, materials and types of construction whose adoption is being contemplated. Plans for further adoption of aluminum and magnesium alloys give a marked indication of the great attention now being paid to weight saving.

As might be expected, more attention is being paid to consumer appeal, as indicated by the fact that nine manufacturers report the contemplated adoption of plating, lacquer finish, or porcelain-enamel finish. This conforms with the expressed intentions of 20 manufacturers to restyle their product to give it more sales appeal through improved form and more pleasing surface finishes. Undoubtedly this is also a factor contributing to the imminent adoption of die-castings and steel stampings. It might appear surprising that no reports indicated the recent or expected adoption of molded plastics. This can be explained by the fact that virtually all of the reports indicated the present use of this material, apparently to such a great extent that the addition of a few more molded parts would hardly seem worth mentioning.

Evidently the manufacturers of home equipment are convinced that the buying public fully appreciates such product refinement as surface finish and appearance, corrosion-resisting materials, easily replaceable units, and devices of pleasing appearance. Undoubtedly, the eight manufacturers engaged in the development of products in a higher price class have in mind products that incorporate the latest engineering refinements, yet redesigned to procure

minimum cost of manufacturing by taking every advantage of the properties of the higher quality materials used. Thus, they aim to offer their superior product in competition on a price basis with the products that have not been redesigned for modern materials and finishes.

Business Machines, Typewriters, Watches, Cameras and Scientific Instruments

In the office equipment field these are days of emphasis on new product development. Every month brings announcements of redesign of product to speed work, to lower operating costs, to eliminate noise, to broaden the usefulness of a machine, to improve accuracy, or to improve appearance. So rapid have these developments come about that the lines of some of the larger and older companies are almost "new" within the last two years.

—N. C. FIRTH
Editor, Management Methods

Although the 34 manufacturers represented in this group serve a widely diversified field, the general nature of the products are in every instance similar. In view of this, it is to be expected that the general character of the product development trends and the emphasis placed upon the various design factors will be similar throughout. The following tabulation gives the number of men employed in engineering design and product development:

NUMBER OF MEN EMPLOYED

1931, first half	133
1931, second half	122
1932, first half	118
Present time	112

The less than 16 per cent drop in personnel, as shown in the above table, is fairly typical of all of the lines represented in this group. Perhaps this is accounted for by the fact that these are mostly small companies, the average engineering personnel for all of the companies being less than four. In the following table is given the relative development activity as reported for these companies:

RELATIVE DEVELOPMENT ACTIVITY

	Companies
Activity greater than 1931	8
Activity greater than 1932, first half	9
Activity less than 1931	14
Activity less than 1932, first half	14
Constant activity throughout the above periods	3
Future Activity	
No change contemplated	23
Increased product development programs	8

The general aim and character of the product development programs of the companies in this group is shown in the following tabulation:

GENERAL CHARACTER OF PRODUCT DEVELOPMENT

	Companies
New products in present line	24
New products in new line	10
Designs for higher price class	6
Designs for lower price class	12
Redesigns chiefly for lower manufacturing costs	17
Designs to provide a greater number of styles or sizes	13
Designs to widen the range of use of the product	13
Designs toward single-purpose equipment	1

In the above tabulation it will be noted that even in this field there is exhibited the same general trend of developing products that will have a wider range of use. Specific design factors that are being emphasized are indicated in the following table:

DESIGN FACTORS EMPHASIZED

	Companies
Higher speeds of operation	9
Larger units	2
More automatic operation	9
Greater precision in use	20
Less power consumption	4
Improved gearing	4
Better electrical control	9
Better springs	5
Improved lubrication	8
Devices or materials to minimize vibration	12
Improved lock washers and locking devices	14
Closer manufacturing tolerances	12
More easily replaceable units	18
Restyling for new form	17
Better surface finish	19
Improved color schemes	8
Materials adopted for improved appearance	16

Considering the above table, it is not to be expected that much emphasis will be given to the development of larger units, improved gearing, or decreased power consumption, as this group of products is not greatly concerned with such factors. The four instances cited wherein decreased power consumption is one of the design factors being emphasized, refer to business equipment.

It is interesting to note the new parts and materials which have recently been adopted for this group of products. In the order of the number of times their adoption was reported, cadmium, chromium, and nickel-plating lead the list with aluminum, cork, Bakelite-treated felt, rubber, molded parts, lacquer finishes, die-castings, glass, welded construction, alloy steel, stainless steels and electric motors, in the order given.

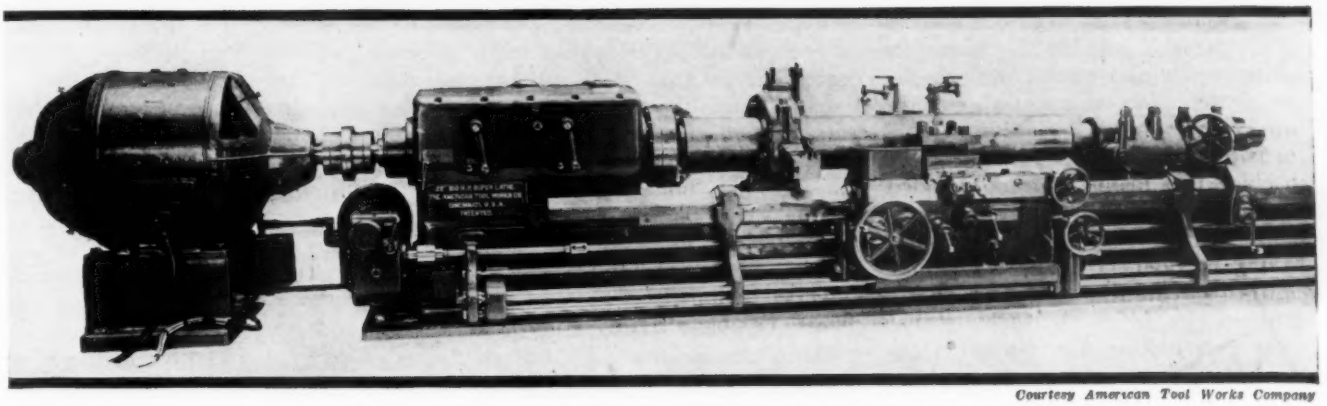
Of greater interest are the items whose adoption is being contemplated. Beginning with those appearing most frequently, magnesium alloys are receiving a tremendous amount of attention, with stainless steels, chromium, cadmium and nickel-plating, flexible shafting, self-lubricating bearings, central lubricating systems, aluminum, fibre and lacquer finishes following in the order given. The most significant item in this last group is the attention being given to lubrication, in spite of the fact that in the above table only eight companies emphasized this factor.

Machinery for the Metal Working Industry

Builders of metal working equipment have operated at barely ten per cent of capacity for months. It is significant of their faith in the future and of their conviction that better machinery will always find a market that their developmental activity has run so far ahead of their operating rate.

—K. H. CONDIT
Editor, American Machinist

This group of 66 manufacturing companies comprises machine tool builders, special machinery manufacturers, manufacturers of small tools and hand tools used in the shop, and seventeen manufacturers representing rolling mill, forge shop, foundry and similar equipment. Their develop-



Courtesy American Tool Works Company

Although this super-powered lathe with 140 spindle speeds was specially designed as a piece of laboratory equipment, some of its design principles relative to simplicity of construction, rigidity, speed control and lubrication might be applicable to production machines

ment activity, over the past two years, is shown by the following tabulation:

RELATIVE DEVELOPMENT ACTIVITY

	Companies
Activity greater than 1931	16
Activity greater than 1932, first half	22
Activity less than 1931	25
Activity less than 1932, first half	24
Constant activity throughout above periods	7
Future Activity	
No change contemplated	37
Increased product development programs	16

During recent months many industrial leaders have emphasized the necessity of creating work for the heavy industries, the opinion being that any substantial gain in general business conditions must come through such channels. Also, all available statistics indicate that these heavy industries have suffered most in this depression. For these reasons, it is particularly interesting to compare the number of men employed in design, research, and product development in the general machine tool industry with the number of men employed in the heavy equipment industries. The following tabulation gives that comparison:

NUMBER OF MEN EMPLOYED

	Heavy Equipment Industry	Machine Tool Industry
1931, first half	918	327
1931, second half	711	300
1932, first half	398	299
Present time	292	245

According to the above tabulation, there has been a drop of about 68 per per cent in engineering personnel in the seventeen companies representing equipment for foundries, rolling mills, forge shops, and similar machinery. This group includes some of the largest manufacturers of this type of equipment in this country, and it is significant that if those companies whose engineering personnel now exceeds 20 men be omitted from the tabulation, the decrease in personnel is only 34 per cent, or exactly one half of the drop for the whole group. However, even this represents a loss almost 50 per cent greater than that suffered by the machine tool industry which shows a decrease of 25 per cent in engineering personnel for the period. Considering all of the above 66 companies, nine increased their personnel and seventeen had the same number of men throughout the different periods.

It is also interesting to note that the eight companies engaged in the manufacture of hand tools and portable shop equipment such as electric hand drills and small portable tools, show a drop of only 11 per cent in engineering personnel throughout the above period. The average number of engineers employed by this group of manufacturers at the present time is slightly more than 6, this being another indication of the remarkable manner in which the small company has succeeded in maintaining a strong product development program in spite of greatly curtailed production activities.

It is not surprising that the machine tool industry should show a relatively better condition than that indicated by the manufacturers of heavy equipment. A study of the other groups of manufacturers reported on in this survey clearly shows that manufacturers of medium sized metal products, household equipment in particular, have not suffered a loss in business to as great an extent as manufacturers of heavy equipment. Apparently, the relatively greater production in the smaller and medium sized plants engaged in the manufacture of various mechanical-electrical consumer products compels these companies to maintain their equipment, providing a market for machine tool builders.

In view of the state of this metal-working equipment industry taken as a whole, as shown by the product development activities, some of the items in the following tabulation of the general character of product development activities, have a special significance.

GENERAL CHARACTER OF PRODUCT DEVELOPMENT

	Companies
New products in present line	51
New products in new line	22
Designs for higher price class	20
Designs for lower price class	28
Redesigns chiefly for lower manufacturing costs	34
Designs to provide a greater number of styles or sizes	18
Designs to widen the range of use of the machine	28
Reduced number of styles and sizes	18

A breakdown of the above tabulation shows that almost one half of the manufacturers in the heavy equipment fields are developing new products in new lines, possibly being forced into doing so by the dearth of business in their present line of products. On the other hand, less than one third of the manufacturers of machine tools are placing particular emphasis upon the development of products in new lines.

The relatively great number of manufacturers who are aiming at a higher price class, and they are mostly in the machine tool industry, can only be interpreted as signifying a demand for machine tools of higher

quality and higher degree of accuracy, to make possible the manufacturing economies made available by the introduction of super-speed cutting tools. Another significant factor is that almost three-fourths of the machine tool manufacturers included in this report are placing great emphasis upon the designs of machines having a wider range of use. This conforms with the views frequently expressed in *American Machinist* that there is a distinct trend away from single purpose machine tools and toward simplified general purpose equipment. This situation is also naturally to be expected when one considers the tremendously frequent and radical changes in product designs which compel complete changes in production toolings.

The manner in which the machine tool and equipment industry is striving to meet the requirements of its customers is indicated by the following table:

DESIGN FACTORS EMPHASIZED

	Companies
Higher speeds of operation	37
Higher capacity units	30
More automatic operation	35
Greater precision in use	36
Decreased power consumption	19
Improved gearing	31
Better electrical control	33
Devices or materials to minimize vibration	23
Improved lubrication	45
Adoption of corrosion-resisting materials	35
Improved lock washers and locking devices	18
Closer manufacturing tolerances	30
More easily replaceable units	30
Restyling for new form	30
Better surface finish	15
Improved color schemes	4
Materials adopted for improved appearance	12

It is naturally to be expected that the first five items in the above tabulation should receive great attention, these being fundamental factors underlying the design of the equipment. It is, however, interesting to note the order of importance attached to the various design items. Thus, improved lubrication, stressed by 45 of the companies in this group, is receiving the greatest attention, with corrosion resisting materials, better electrical control, improved gearing, closer manufacturing tolerances, more easily replaceable units, and restyling for new form, following in the order given.

New parts and materials recently adopted or whose adoption is being contemplated can, in most instances, be explained by the general character of the product development and the design factors that are being emphasized. Thus, the greatest attention being given to the development of general purpose machines having a wider range of use, undoubtedly corroborates the many instances of recent and contemplated adoption of clutches, V-belts, flat belts, flexible couplings, universal joints, silent and roller chains, flexible shafting and variable speed transmissions. In line with automatic operation and lubrication of products, three companies have recently, and six companies contemplate, the adoption of pumps and controls for hydraulic operation to be incorporated in their products.

Improved lubrication is being aimed at principally through the adoption of central lubricating systems, adopted or contemplated by 11 companies, while gun-type and self-lubricating bearings and oil filters are also receiving attention. More than a dozen companies are increasing their use of aluminum and its alloys, while stainless steels are receiving about equal attention, these items reflecting the emphasis that is being placed on corrosion resistance.

As to other construction materials and methods, alloy steels, alloy cast iron, and steel castings, lead the list of materials recently adopted or whose adoption is being contemplated. Welded construction, rolled, drawn or extruded shapes, fibre, rubber, and molded parts follow in the order given. Although electric motors are not new to this group of products, it is not surprising that considerable attention is reported being given to geared head motors and electric motors built into the machines.

Manufacturing Equipment for Non-Metal Products

In the textile machinery industry manufacturers within the last three months have begun to experience the results of the intensive product development programs of '27 to '29, the vastly improved equipment now compelling machinery replacement programs that otherwise would not have been considered.

—D. G. WOOLF
Editor, Textile World

Included in this group of 30 companies are manufacturers of woodworking, textile, industrial laundry, hat-making, paper-working, shoe and box-making machinery. Relative activity in product development in this group of manufacturing companies is indicated in the following table:

RELATIVE DEVELOPMENT ACTIVITY

	Companies
Activity greater than 1931	9
Activity greater than 1932, first half	5
Activity less than 1931	12
Activity less than 1932, first half	12
Constant activity throughout above period	6
Future Activity	
No change contemplated	26
Increased product development programs	6

The number of men engaged in design, research and product development during the successive periods indicated is given in the following tabulation:

NUMBER OF MEN EMPLOYED

1931, first half	213
1931, second half	193
1932, first half	167
Present time	143

Although several large manufacturers are included in this group, the 33 per cent drop in personnel as indicated in the above table represents the average condition throughout the industry. Unlike so many of the other groups, the larger companies in this field do not show a drop in personnel appreciably greater than the average. Nine of the companies had a constant personnel throughout the above period while three of the companies have increased their engineering staffs since January 1931.

Because of the numerous different individual industries that are being served by this group of manufacturers, it would be impossible to draw any general conclusions concerning the expressed aims in the product development programs as given in the following tabulation:

GENERAL CHARACTER OF PRODUCT DEVELOPMENT

	Companies
New products in present line	26
New products in new line	14
Designs for higher priced class	2
Designs for lower priced class	17
Redesigns chiefly for lower manufacturing costs	21

Increased number of styles or sizes	10
Fewer number of styles or sizes	11
Designs to widen the range of use of the machines	15
Redesigns towards single purpose machines	1

In the above tabulation will be noticed the same general trends as exhibited in the product development activities in the machine tool industry, namely, lower priced machines produced at a reduced cost to serve a wider variety of uses, with a very distinct trend away from the single purpose machine.

Although almost one-half of the companies are reported as developing new products in a new line, information given on the questionnaire indicates that the new lines of products are in the same general field. Thus, the manufacturers of laundry machinery are apparently increasing their lines of equipment to serve their field better.

With reference to the particular items of engineering design that are receiving the most attention, the following table indicates the relative importance attached to the various factors:

DESIGN FACTORS EMPHASIZED

	Companies
Higher speeds of operation	20
Larger and heavier units	7
More automatic operation	14
Greater precision in use	12
Decreased power consumption	16
Improved gearing	11
Better electrical control	14
Better springs	6
Devices or materials to minimize vibration	15
Improved lubrication	14
Adoption of corrosion-resisting materials	16
Improved lock washers and locking devices	8
Closer manufacturing tolerances	10
More easily replaceable units	17
Restyling for new form	9
Better surface finish	8
Improved color schemes	3
Materials adopted for improved appearance	6

Considering only the 21 reports that gave information concerning new materials and parts recently adopted or whose adoption is being contemplated, the following tabulation indicates some of the specific methods of meeting the design requirements that are being emphasized:

NEW PARTS AND MATERIALS RECENTLY ADOPTED OR CONTEMPLATED

(Based Upon 21 Reports)

	Companies
Stainless steel	8
Aluminum alloys	5
Magnesium alloys	2
Alloy cast iron	6
Alloy steel	7
Welded construction	7
Self-lubricating bearings	10
Central lubricating systems	5
Anti-friction bearings	6
Individual electric motor drives	7
V-belts	8
Variable-speed transmissions	7
Speed reducers	4
Rubber, cork, or fibre	6
Auxiliary control apparatus	5
Pumps and controls for hydraulic operation (*all contemplated*)	3

In addition to the above, there are scattered instances of two or more recent or contemplated adoptions of flexible couplings, universal joints, flexible shafting, electric heating units, welded construction, rolled, drawn or extruded shapes, porcelain enamel finish, various plating finishes, roller and silent chains, gun-type lubrication.

With reference to the numerous new applications of self-lubricating bearings, these were accounted for almost entirely in the textile and hat-making machinery companies. On the other hand, the numerous new applications of electric motors are accounted for in industries other than textile, shoe and hat-making machinery.

One of the most significant items in the above tabulation is the contemplated adoption of pumps and controls for hydraulic operation. One of each of these contemplated adoptions was reported by a manufacturer of stone-working machinery, paper-handling machinery, and woodworking machinery. Whether this is indicative of forthcoming general trends in each of those three lines of manufacture, cannot be established on the basis of only these three instances.

Machinery and Equipment for the Food Industries

Of special interest to me is that this summary shows that equipment manufacturers are alert to the expressed needs of the food industry for more flexible machines capable of continous functioning with low cost of upkeep, and incorporating corrosion-resistant materials to a greater extent in order to improve sanitary conditions.

—L. V. BURTON
Editor, Food Industries.

The 24 companies in this group represent builders of automatic packaging and wrapping machines, bake ovens, washers, dairy and bottling equipment, and retail stores equipment. For the period from January 1931 to date, the relative product development activity is indicated by the following tabulation:

RELATIVE DEVELOPMENT ACTIVITY

	Companies
Activity greater than 1931	10
Activity greater than 1932, first half	9
Activity less than 1931	3
Activity less than 1932, first half	6
Constant activity throughout above periods	7

A more exact measure of the comparative intensity of effort now being put on product development in this field is given by the following tabulation showing the average number of men engaged in design, research and product development during the periods specified:

NUMBER OF MEN EMPLOYED

First half, 1931	165
Second half, 1931	151
First half, 1932	139
Present time	137

Although these figures show a drop of 17 per cent in the number of men employed, more detailed study of the questionnaires shows that out of the 24 reporting companies, nine companies, averaging 5 men now on the staff, have the same number of men now engaged in engineering as they had in the first half of 1931, while five companies, averaging 8 men now on the staff, have increased their personnel by an average of exactly 100 per cent since the first half of 1931. The largest company showed a drop of 60 per cent in its staff. Excluding this one company, there has been an increase in the number of engineers employed of 2 per cent over the first half of 1931, and 8 per cent over the first half of 1932. It is also interesting to note that the average number of men now in the engineering and development departments of the 24 companies included in this survey, is about 6, this being an indication of the great number of small or medium-sized plants in this line of manufacture.

Increased product development activity is contemplated by five of the

companies. One-third of the companies are developing entirely new lines of products. The continued and increased activity in this field of manufacture is apparently a reflection of the great strides that are being made in the methods of preparing and marketing food. Considering both the present and new lines of products, the general character of the product development activity is shown by the following tabulation:

GENERAL CHARACTER OF PRODUCT DEVELOPMENT

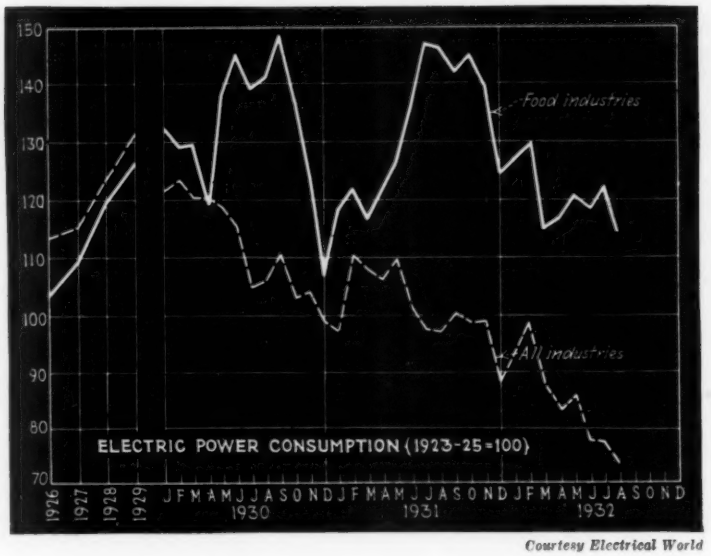
	Companies
Higher price class	1
Lower price class	14
Reduced cost of manufacturing	12
Greater number of styles	11
Simplification of the product line	8
Designs to widen the range of use of the machine	16

The specific manner in which the product development program aims to improve the designs in order to increase the salability of the product is indicated as follows:

DESIGN FACTORS EMPHASIZED

	Companies
Higher speeds of operation	13
Larger and heavier machinery	4
More automatic operation	18
Greater precision in use	18
Decreased power consumption	7
Improved gearing	9
Better electrical control	10
Better springs	2
Devices or materials to minimize vibration	13
Better lubrication	17
Adoption of corrosion-resisting materials	19
Improved lock washers and locking devices	10
Closer manufacturing tolerances specified	11
More easily replaceable units	15
Restyling for new form	10
Better surface finish	11
Improved color schemes	4
Materials adopted for improved appearance	11

New parts and materials recently adopted to meet the design requirements to fulfill the specified aims of the product development program as indicated in the above tabulation include: stainless steels, copper-nickel alloys, Monel and aluminum and its alloys, (these probably having been selected primarily for their corrosion-resisting properties). Chromium-plating, cadmium-plating, nickel-plating and lacquer finishes have received a wide adoption, both for corrosion resistance and improved appearance. In line with this, there has been a marked increase in the use of die-castings, pressed metal parts and molded parts. This industry also shows the general trend exhibited in almost all lines of machinery manufacturing in that there has been a quite general adoption of alloy steels and high-strength alloy cast iron. It is also significant that almost one-third of the companies reporting on newly adopted methods of construction have taken up welding.



Courtesy Electrical World

Electric power consumption is a combined measure of the degree of mechanization and rate of operation. Compared to 1926, its increase in the food industries is evident, being indicative of the increasing adoption of machinery

Undoubtedly, the desire to minimize vibration, as expressed by thirteen of the questionnaires, accounts for the many recent adoptions of rubber and cork.

Looking into the future, it is significant that some of the companies are contemplating the adoption of rolled, drawn or extruded shapes, which is right in line with the recent adoption of more welded construction. Also the expressed contemplated adoption of die-castings, molded parts and pressed metal parts, is not dictated entirely by the desire for the most economical construction, but also by the desire to use materials that contribute to a generally improved appearance.

Of considerable interest is the fact that in addition to the further use of aluminum and its alloys, one manufacturer is contemplating the adoption of magnesium alloys. Besides chromium-plating and lacquer finishes, as contemplated by several of the manufacturers, porcelain-enamel is being considered.

Conforming to the expressed desire for higher speeds, more automatic operation, and better gearing and control it is to be expected that pumps and controls for hydraulic operation, variable-speed transmission, central lubricating systems, flexible shafting, self-lubricating bearings and ball or roller bearings are being contemplated.

Power Plant and Pumping Machinery

Immediate requirements are not for greater units but smaller equipment of lower capacity and high efficiency with low maintenance cost for isolated plant installations. The growth of public utilities in the last year can be attributed practically entirely to increased domestic consumption. More power is being generated in industrial plants which are doing all they can to decrease their costs by the use of the best equipment obtainable.

—ELY C. HUTCHINSON
Editor, Power

In this group are included 35 manufacturers of stationary pumps and engines, boilers, economizers, stokers, and power plant and water works equipment exclusive of temperature and pressure recording instruments. These last items are included under a separate group be-

cause of their overlapping with the chemical and processing industries. Even with this division there is some overlap with the chemical and processing industries, but the various companies were segregated, in so far as possible, on the basis of the principal market that each covered.

The average number of men employed in the design, research and product development, during the successive six months' periods beginning with January 1931, is shown by the following tabulation:

NUMBER OF MEN EMPLOYED

1931, first half	349
1931, second half	323
1932, first half	307
Present time	254

Although the 35 manufacturers represented in this analysis show an average drop of about 27 per cent in their present product development personnel as compared to January 1931, eight of the companies in this group show the same size of engineering development staff throughout this same period. Furthermore, although the above tabulation shows a 17 per cent drop in personnel since the first half of this year, eight of the companies increased their staff in the past few months. More light is thrown on this question by the relative development programs for the various periods as given in the following table:

RELATIVE ACTIVITY

	Companies
Activity greater than 1931	11
Activity greater than 1932, first half	17
Activity less than 1931	17
Activity less than 1932, first half	11
Constant activity throughout above periods	1
Same activity as first half of 1932	4
Future Activity	
No change contemplated	27
Increased product development programs	6

It is not expected that there will be an exact agreement between the above two tables because the number of men employed is not an exact gage of the degree of product development activity. This is brought about by part-time or over-time work, a change in activity which is not reflected in the number of men employed.

General trends in the product development activities of the companies reported on in this group are shown by the following tabulation:

GENERAL CHARACTER OF PRODUCT DEVELOPMENT

	Companies
New products in present line	30
Products in new line	12
Designs for higher price class	4
Designs for lower price class	27
Redesigns chiefly for lower manufacturing costs	23
Designs to provide a greater number of styles or sizes	14
Designs to widen the range of use of the machine	25

Courtesy Electrical World

Production of power reached its low point in July. Since then, this barometer of industrial activity has risen almost uninterruptedly until now it has again reached the level of last April's consumption

Although twelve companies are listed above as developing new products in a new line, notations on the questionnaires clearly show that the new products are not in a new field, but rather additional designs of the present line of products in order to increase their field of use. Thus, one manufacturer of reciprocating pumps is developing condensation return systems, and a manufacturer of centrifugal pumps is adding gear pumps to his line. This interpretation is also borne out by the fact that 25 of the companies are redesigning their products so that they will cover a wider range of operations or use.

Increase of sales through improved products is being aimed at by redesign wherein emphasis is being placed upon specific items as follows:

DESIGN FACTORS EMPHASIZED

	Companies
Higher speeds of operation	10
Higher capacity units	4
More automatic operation	11
Greater precision in use	13
Decreased power consumption	15
Improved gearing	4
Better electrical control	15
Devices or materials to minimize vibration	13
Improved lubrication	20
Adoption of corrosion-resisting materials	29
Improved lock washers and locking devices	5
Closer manufacturing tolerances	17
More easily replaceable units	18
Restyling for new form	14
Better surface finish	8
Materials adopted for improved appearance	13

As will be observed in the above tabulation, the greatest emphasis is being placed upon the adoption of corrosion-resisting materials, more easily replaceable unit parts, improved lubrication and efficiency of operation. In addition, a check-off on the list of parts and materials, types of construction, and finishes, which have been adopted recently or whose adoption is being contemplated, indicates a strong trend toward welded construction and the use of alloy cast-iron and steels, with stainless steels taking a leading part. In some instances there has been an adoption of aluminum and magnesium alloys, apparently to meet corrosion conditions. Possibly for the same reason, or to improve appearance, chromium, cadmium and nickel plating have been adopted, while one company reported the adoption of stellited surfaces for wear resistance.

Numerous other materials whose recent adoption was reported include gun-type lubrication, V-belt drives, bronze shafting with steel cores, and pressed metal parts.

Of course in a field of equipment whose mechanical design is so diversified, many parts and materials have only a special application in a particular product.

Process Industries and Oil-Field Equipment

What impresses me most is the degree of development activity shown by this report. Evidently these manufacturers have continued their activities in the face of declining markets, continually redesigning to incorporate the latest improvements in materials and parts. As the chemical industry handles the most corrosive types of materials, it is not surprising to find a strong interest in the adoption of corrosion-resisting metals and alloys.

—S. D. KIRKPATRICK
Editor, Chemical & Metallurgical Engineering

Considerable difficulty was experienced in segregating these plants from the manufacturers of power plant equipment because many of the latter have in recent years gone into the manufacture of stills, condensers, heat exchangers and similar apparatus for the processing industries. Of the sixteen companies summarized in this group, only five are engaged solely in the manufacture of equipment for processing, while ten are manufacturers of oil field and refinery equipment.

Considering the sixteen plants in this group, the number of men employed in design, research and product development, during the successive six months' period beginning with January, 1931, is shown by the following table:

NUMBER OF MEN EMPLOYED

1931, first half	190
1931, second half	177
1932, first half	140
Present time	136

According to the above figures, the total drop in personnel compared with January 1931, is 33 per cent. If the one largest company is omitted from the tabulation, the decrease in the number of men employed in engineering, research and design is only 13 per cent. One company shows an increased engineering staff, while three companies had the same number of men throughout the period tabulated. Two of these last companies averaged thirteen men continuously employed. Concerning the relative development activities for the different periods, which does not necessarily agree with the number of men employed because of the part-time element, the following tabulation gives the number of companies whose relative activity is as indicated:

RELATIVE DEVELOPMENT ACTIVITY

	Companies
Activity greater than 1931	2
Activity greater than 1932, first half	5
Activity less than 1931	8
Activity less than 1932, first half	4
Constant activity throughout above periods	3
Future Activity	
No change in activity contemplated	9
Increased product development programs	3

For this group, the general trends in the product development activities are shown by the tabulation following:

GENERAL CHARACTER OF PRODUCT DEVELOPMENT

	Companies
New products in present line	14
New products in new line	3
Design for higher price class	2
Design for lower price class	10
Redesign chiefly for lower manufacturing costs	10
Design to provide a greater number of styles	8
Design to widen the range of use of the equpiment	4

The specific design factors which are receiving the greatest attention in order to meet the above tabulated general aims of the product development program are indicated in the following tabulation which gives the number of companies that are emphasizing the design factors indicated:

DESIGN FACTOR EMPHASIZED

	Companies
Higher speeds of operation	5
Larger and heavier machinery	4
More automatic operation	5
Greater precision in use	4
Decreased power consumption	5
Improved gearing	5
Better electrical control	2
Better springs	1
Devices or materials to minimize vibration	1
Improved lubrication	4
Adoption of corrosion-resisting materials	7
Closer manufacturing tolerances	5
More easily replaceable unit parts	7
Restyling for new form	2
Better surface finish	1
Materials adopted for improved appearance	1

As is to be expected, the greatest attention is being paid to the problem of corrosion. Although only six of the questionnaires gave any information on the new parts and materials recently adopted or whose adoption is being contemplated, there were five instances wherein the adoption of aluminum or its alloys has taken place, with almost an equal number of adoptions of stainless steels and various platings. Although these last are not satisfactory for general corrosion-resistance, undoubtedly there have been some applications of it for the purpose of increasing ordinary rust resistance. Other items that are receiving considerable attention are magnesium alloys, rolled, drawn, or extruded shapes, wood, plywood and pressed wood. Electric heating units and variable-speed drives are also being considered.

Construction and Mining Equipment

Active advance in equipment production and the creation of new machines performing new functions is characteristic of the construction field. This advance has not only continued since 1929 but in many instances has been accelerated, though the sharp reduction in construction volume during the last twelve months has necessarily limited its scope, as these survey results reflect. The nature of current improvement work also is well indicated by the survey, which shows that interest is centered on new products, wider range of use and more rugged and serviceable construction. With a prospective increase in construction demand next year a return to full development programs may be expected.

—F. E. SCHMITT
Editor, Engineering News-Record

In this group of 30 companies are included manufacturers of steam shovels, dragline scrapers, mining machinery and similar equipment. Although there is no apparent connection between construction and mining yet the equipment is similar, and most of the manufacturers of this type of equipment serve both fields. Considering this whole group, the average

number of men employed in design, research and product development, during the successive periods indicated, is shown in the following tabulation:

NUMBER OF MEN EMPLOYED

1931, first half	459
1931, second half	387
1932, first half	274
Present time	220

The total drop in employment, 50 per cent, is somewhat greater than that shown by any other individual group in this summary. In the field of construction equipment, the drop in engineering personnel is 60 per cent, while in the manufacture of mining equipment it is 32 per cent. Considering the relative activities for the various periods, this is shown by the following table:

RELATIVE DEVELOPMENT ACTIVITY

	Companies
Activity greater than 1931	8
Activity greater than 1932, first half	8
Activity less than 1931	13
Activity less than 1932, first half	12
Constant activity throughout above periods	3
Future Activity	
No change contemplated	22
Increased product development programs	8

The general character and aims of the present product development programs are shown by the following tabulation:

GENERAL CHARACTER OF PRODUCT DEVELOPMENT

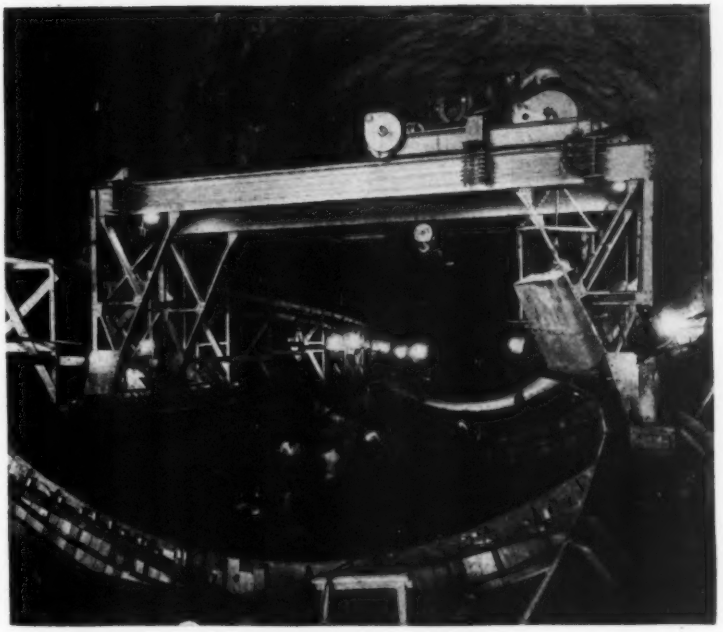
	Companies
New products in present line	27
New products in new line	11
Designs for higher price class	3
Designs for lower price class	15
Redesigns chiefly for lower manufacturing costs	16
Designs to provide a greater number of styles or sizes	6
Designs to widen the range of use of the machine	24
Designs toward single-purpose equipment	1

The above tabulation reflects the well-recognized trend toward flexible equipment that can be used for a variety of purposes or under widely different conditions, a trend similar to that in the machine-tool and metal-working equipment industries.

The specific design factors that are being emphasized in this product development program are shown in the following table:

DESIGN FACTORS EMPHASIZED

	Companies
Higher speeds of operation	20
Larger capacity units	11
More automatic operation	11
Greater precision in use	8
Less power consumption	12
Improved gearing	17
Better electrical control	9
Better springs	4
Devices or materials to minimize vibration	11
Improved lubrication	24
Adoption of corrosion-resisting materials	19
Improved lock washers and locking devices	21
Closer manufacturing tolerances	17
More easily replaceable units	21
Restyling for new form	10
Better surface finishes	10
Improved color schemes	5
Materials adopted for improved appearance	15



For the first time, gantry cranes are being used in tunneling. The one shown here handles muck skips, forms and concrete in lining the invert section of one of the 56-ft. diameter diversion tunnels at the Hoover Dam

The manner in which these factors are being provided for in the design of new machinery is reflected in the new parts and materials that have recently been adopted or whose adoption is being contemplated. Considering only those new parts and materials that have been adopted recently, alloy steels, alloy cast iron, aluminum alloys and magnesium alloys have each been adopted in five or more instances among the 27 companies that have reported on this question. Other items that recurred two or more times include: V-belts and flat belts, pressed metal parts, chromium-plating, gun-type lubrication, ball and roller bearings, central lubricating systems and molded parts. Six companies reported the recent adoption of further welded construction.

With reference to the parts, materials and types of construction whose adoption is being contemplated, six companies are considering alloy cast iron, five companies aluminum or its alloys, while the following items appear three or more times: alloy steels, auxiliary control apparatus, pressed metal parts, welded construction, self-lubricating bearings, silent chains, speed reducers, die-castings, forgings, ball or roller bearings, rubber, cork, gasoline-engine drive, flexible couplings and shaftings, and V-belts. Oil filters are also receiving considerable attention.

The contemplated wider use of alloy cast iron, aluminum alloys, and alloy steels conforms to the aim for larger capacity and speedier units, this last calling for better gearing, improved lubrication, less vibration, improved lock washers and locking devices, and a more efficient use of power, with closer manufacturing tolerances throughout. Higher speeds and better electrical control with more automatic control go hand in hand.

More easily replaceable units to minimize lost time through breakdowns is naturally receiving great emphasis, but many will undoubtedly be surprised at the amount of attention that is being given to improved appearance. Perhaps the general recognition of the fact that a design "that looks good usually is good" is a contributing factor in this instance.

Electric Motors, Machine Drives and Controls

Prior to 1930, there was a pronounced tendency to overlook the potential economies of tributary equipment. But with present curtailed output and a highly competitive market, reliance must be placed upon net profits from fewer operating units, making savings more important. Therefore electric motors and controls, and mechanical power transmission equipment of all kinds will be subjected to the same careful analytical examination that was formerly reserved for strictly production equipment. —L. C. MORROW
Editor, Maintenance Engineering

In this group are included 23 manufacturers of electric motors, motor controls, speed reducers, gear pumps, variable-speed drives and similar units.

The average number of men employed in design, research, and product development, during the successive six months' periods beginning with January 1931, is shown by the following tabulation:

NUMBER OF MEN EMPLOYED

1931, first half	193
1931, second half	151
1932, first half	134
Present time	126

As is true in most other fields, although the 23 reporting companies show a drop in engineering personnel of almost 35 per cent, as compared to January 1931, if the largest companies are taken out of the tabulation, in this instance two companies, the per cent drop in personnel is considerably less. Thus, omitting the two largest companies in this group, the drop in engineering personnel is only 17 per cent. Also, nine of the companies have a larger engineering staff now than they had in January 1931, while five of the companies show no change in the number employed. The fact that most of the increases in personnel took place since the first half of this year, seems to indicate increasing activity among at least the smaller plants.

The relative status of product development programs is given in the following table:

RELATIVE DEVELOPMENT ACTIVITY

	Companies
Activity greater than 1931	7
Activity greater than 1932, first half	8
Activity less than 1931	10
Activity less than 1932, first half	7
Constant activity throughout above periods	3
Future activity	
No change contemplated	21
Increased product development programs	2

Of considerable interest are the general aims of the product development activity, which are shown in the following tabulation:

GENERAL CHARACTER OF PRODUCT DEVELOPMENT

	Companies
New products in present line	18
New products in new line	5
Designs for higher price class	3
Designs for lower price class	13
Redesigns chiefly for lower manufacturing costs	7
Designs to provide a greater number of styles or sizes	13
Designs to widen the range of use of the product	9

In conjunction with the general aims of the product development programs, it is interesting to note the specific design factors that are receiving greatest attention. Thus, for the 23 companies included in this summary, particular emphasis is being placed upon specific items or phases of design as indicated in the following table:

DESIGN FACTORS EMPHASIZED

	Companies
Higher speeds of operation	5
Larger units	1
More automatic operation	5
Greater precision in use	5
Decreased power consumption	6
Improved gearing	5
Better electrical control	6
Better springs	3
Devices or materials to minimize vibration	6
Improved lubrication	8
Adoption of corrosion-resisting materials	6
Improved lock washers and locking devices	5
Closer manufacturing tolerances	6
Adoption of more easily replaceable units	4
Restyling for new form	10
Better surface finish	6
Materials adopted for improved appearance	7

In line with the design factors that are receiving the greatest attention as indicated in the above table, the emphasis placed on combating corrosion is reflected in numerous recent and contemplated adoptions of stainless steel and non-ferrous corrosion-resisting materials. Although weight is usually not an appreciable factor in this line of products, numerous instances of recent or contemplated adoption of magnesium alloys and

With appearance, lightness and quiet operation the dominating factors, recent improvements in escalators include zinc alloy die-cast treads, extruded moldings for the balustrades, zinc die-cast step-yokes and canvas cushion wheels

Courtesy Otis Elevator Company

aluminum alloys were also reported.

Alloy cast iron and alloy steels are evidently receiving a tremendous amount of attention, as indicated by the results of this survey. On the other hand, there is apparently relatively little attention being given to welded construction, which fact can readily be understood when one considers the nature of the products in this field.

Approximately one-fourth of the companies are placing particular emphasis upon the isolation of vibration, which accounts for the numerous reported instances of recent and contemplated adoption of rubber and cork. Similarly, with more than one-third of the companies aiming at improved lubrication, it is not surprising that oil filters, oil seals, central lubricating systems, self-lubricating bearings and gun-type lubrication are coming into more general use, numerous recent and contemplated adoptions having been reported. In line with the desire for improved appearance, cadmium-plating, chromium-plating and lacquer finishes are receiving considerable attention.

With the ever-increasing importance that is being attached to the connecting drive between the motor and the driven machine, V-belts, universal joints, flexible shafting, speed reducers and variable-speed transmissions are finding numerous new applications.

Plant and Building Equipment

Now is the time that designing engineers can not only create confidence in their ability to develop new products, but they also have the opportunity to build a morale into the whole organization by making sales, factory and advertising managers and everyone else realize how new designs stimulate sales.

—J. M. CARMODY
Editor, Factory & Industrial Management

Included in this group of 21 companies are manufacturers of such products as passenger and freight elevators, escalators, cranes, plumbing goods, heating and ventilating equipment for commercial buildings and factories, and products in similar lines. The relative activities of these companies as reflected by the number of men engaged in design, research and product development during the periods indicated, is shown by the following tabulation:

NUMBER OF MEN EMPLOYED

1931, first half	216
1931, second half	202
1932, first half	191
Present time	175

It is rather surprising that this shows a drop of only 19 per cent in the engineering personnel. Furthermore, if the two largest companies be omitted from the tabulation, the number of development engineers employed in the respective periods is 75, 71, 80 and 78. This last shows a slight increase in personnel, with the low point having been reached in the second half of 1931, which is explained by the fact that one manufacturer of elevator equipment increased his engineering staff by 12 men, and a manufacturer of plumbing goods increased his staff by 4 men, the remaining companies showing in most instances small decreases in personnel throughout the four periods. Furthermore, it must be considered that building equipment activities probably experienced their greatest drop prior to 1931, and therefore it is not to be expected that there would be much further decrease in activities since that time.

The general state of the relative activity is further shown by the following tabulation:

RELATIVE DEVELOPMENT ACTIVITY

	Companies
Activity greater than 1931	6
Activity greater than 1932, first half	6
Activity less than 1931	6
Activity less than 1932, first half	4
Constant activity throughout the above periods	5
Future Activity	
No change contemplated	18
Increased product development programs	3

It will be observed that this second table conforms to what might be expected from the figures given for the number of product engineers employed.

General trends in the product development activities of the companies reported on in this group are shown by the following tabulation:

GENERAL CHARACTER OF PRODUCT DEVELOPMENT

	Companies
New products in present line	19
New products in new line	6
Designs for higher price class	6
Designs for lower price class	8
Redesigns chiefly for lower manufacturing costs	11
Designs to provide a greater number of styles or sizes	8
Designs to widen the range of use of the equipment	7
Designs toward single-purpose equipment	0

In the above tabulation it will be noted that this industry exhibits the same trend as that shown in most of the other equipment manufacturing fields, namely, there is a strong tendency toward more flexible machinery that can be used for a variety of purposes.

Considering the design factors that are receiving the greatest attention in order to bring about the general aims of the product development programs, the following tabulation gives the number of companies emphasizing the factors specified:

DESIGN FACTORS EMPHASIZED

	Companies
Higher speeds of operation	3
Larger and heavier equipment	3
More automatic operation	4
Greater precision in use	5
Decreased power consumption	2
Improved gearing	3
Better electrical control	7
Better springs	1
Devices or materials to minimize vibration	7
Improved lubrication	3
Adoption of corrosion-resisting materials	2
Improved lock washers and locking devices	3
Closer manufacturing tolerances	4
More easily replaceable units	8
Restyling for new form	11
Better surface finishes	9
Improved color schemes	2
Materials adopted for improved appearance	8

Naturally, it is to be expected that improved electrical control will be one of the dominating factors considered in the design of elevators, escalators, and similar equipment. Hand in hand with it, and receiving equally great attention, is the continued effort toward minimizing vibration, particularly by the companies manufacturing passenger elevators where noise is such an important factor. Also, the exceptional amount of attention that is being given to the form of the product and its surface finish is merely a reflection of the importance that is being attached to

the appearance of both buildings and their equipment.

In the quest for attaining the product improvements, as indicated in the above table, manufacturers in this group are contemplating further adoption of die-castings, aluminum and magnesium alloys, rolled, drawn or extruded shapes, alloy steels, cork and rubber, which reflects the importance that is being attached to lightness of construction, absence of vibration, and general appearance. That surface finish is receiving a great amount of emphasis is indicated by the fact that there are many reported contemplated adoptions of porcelain-enamel finish, lacquer finishes, japan finishes and, particularly, plating. In addition to the above items many others were mentioned as receiving consideration for adoption, the above list enumerating only those that are receiving the greatest attention.

Devices or materials to minimize vibration	6
Improved lubrication	11
Adoption of corrosion-resisting materials	19
Improved lock washers and locking devices	5
Closer manufacturing tolerances	11
More easily replaceable units	10
Restyling for new form	18
Better surface finish	16
Improved color schemes	6
Materials adopted for improved appearance	11

Miscellaneous Products and Equipment

In this group of 38 companies are included five manufacturers of farm machinery, in addition to manufacturers of specialties and other products that cannot be included in any of the eleven preceding groups. On account of the great variety of products represented here, the tabulations will indicate merely general conditions. Taking the whole of the group, the average number of men employed is shown in the following tabulation:

NUMBER OF MEN EMPLOYED

1931, first half	408
1931, second half	278
1932, first half	301
Present time	286

It will be noted that the above table shows a tremendous drop between the first and second half of 1931, following which there is an appreciable rise followed by another drop, the low point having been reached in the second half of 1931. Since the first half of 1931, the number of engineers now employed shows a drop of 30 per cent. However, the five manufacturers of farm equipment or machinery show a loss of 39 per cent in personnel for this period, and if these five companies be omitted from the tabulation, the drop in employment for the remaining companies would be only 24 per cent.

In the following table is given the relative development activity for the periods indicated:

RELATIVE DEVELOPMENT ACTIVITY

	Companies
Activity greater than 1931	13
Activity greater than 1932, first half	13
Activity less than 1931	10
Activity less than 1932, first half	11
Constant activity throughout the above periods	3
Future Activity	
No change contemplated	25
Increased product development programs	15

With reference to the general character of the product development activities, these are indicated in the following tabulation:

GENERAL CHARACTER OF PRODUCT DEVELOPMENT

	Companies
New products in present line	24
New products in new line	11
Designs for higher price class	9
Designs for lower price class	11
Redesigns chiefly for lower manufacturing costs	20
Designs to provide a greater number of styles or sizes	12
Designs to widen the range of use of the product	17

Design factors that are being emphasized in order to attain the aims as set forth in the above table are as follows:

DESIGN FACTORS EMPHASIZED

	Companies
Higher speed of operation	13
Larger or heavier units	4
More automatic operation	7
Greater precision in use	12
Decreased power consumption	11
Improved gearing	4
Better electrical control	5
Better springs	1

This group of manufacurers of miscellaneous products reflects the same general tendencies shown in the preceding group with reference to the adoption of new parts and materials. Beginning with the materials whose recent adoption was reported most frequently, stainless steel heads the list, followed by platings, rolled, drawn, or extruded shapes, rubber, aluminum or its alloys, self-lubricating bearings, central lubricating systems, gun-type lubrication, roller chains, ball or roller bearings, lacquer finishes, flexible shafting, die-castings, fibre, cork, brass, bronze, and additional miscellaneous items.

Of greater interest are the parts and materials whose adoption is being contemplated. In this group, electroplating heads the list with rubber a close second, following which come aluminum, die-castings, rolled, drawn or extruded shapes, cork, ball or roller bearings, alloy cast iron, speed reducers, bronze, pressed metal parts, welded construction, flexible couplings, V-belts and flat belts, fibre, forgings, lacquer finishes, oil filters, electric motor drives, copper-nickel alloys, roller chains, stainless and alloy steels, steel castings, universal joints and a number of miscellaneous materials.

General Status and Trends

Considering all of the 430 companies that are included in the above twelve groups of industries, the following tables indicate the status of the relative development activity and the number of men engaged in design, research and product development during the periods specified:

RELATIVE DEVELOPMENT ACTIVITY

	Companies
Activity greater than 1931	131
Activity greater than 1932, first half	138
Activity less than 1931	162
Activity less than 1932, first half	142
Approximately constant activity	50
Future activity	
No change in activity contemplated	285
Increased product development programs	98

NUMBER OF MEN EMPLOYED

First half, 1931	5,616
Second half, 1931	5,079
First half, 1932	4,284
Present time	3,662

Relative to the number of men employed, these figures show a drop of 35 per cent when compared with January, 1931. However, omitting 16 companies that showed the greatest drop in engineering personnel,

Never before have conditions compelled so great an attention to product development. New lines are being created and old ones improved, with values measured by serviceability, durability and beauty. And the central figure in all this activity is the product engineer. This is his opportunity. His success in creating attractive products that contribute to the needs and desires of mankind will be reflected in increased prestige both for himself and for his profession

this decrease in the number of men is slightly less than 24 per cent. These 16 companies average 29 men now engaged, the drop in their engineering personnel since January, 1931 being slightly above 67 per cent.

In considering these figures on the relative loss of engineering personnel in the large companies as compared with the small companies, it must not be concluded that the larger companies have decreased their engineering development work to a greater extent than the smaller companies. Under normal business conditions, a large company requires a correspondingly great number of men in their engineering department to put through the routine work. When production decreases, there is no longer any need for the many men in the engineering department whose duties are primarily to put through engineering changes or revising designs to customers' specifications. This is particularly true in industries such as manufacturers of chemical equipment, general factory equipment and rolling mills and hydraulic presses for the iron and steel industries, such products usually being designed to meet specific conditions. Therefore, any decrease in business activity will be promptly reflected in a correspondingly great decrease in engineering personnel.

On the other hand, considering the plants having relatively small engineering departments, it will usually be found that the percentage of the men engaged in product development work is considerably higher than in the larger companies. Furthermore, as the key men, such as chief engineer, chief draftsman and estimator comprise a large percentage of the force, it is apparent that a great percentage in staff reduction cannot readily be made without seriously endangering the effectiveness of the engineering and development work.

In line with this, another fact in the above analysis emphasizes that decreased business does not necessarily mean decreased engineering activities. In the household equipment group, the chart by *Electrical Merchandising* giving the volume of sales for all electrical merchandise shows a drop in dollar volume of business for the year 1931. Yet, exclusive of companies solely engaged in radio manufacture, the drop in engineering personnel has been only 13 per cent, while, further excluding the two largest companies from the tabulation, there has been an actual increase of 2 per cent in the number of men engaged in product development in this industry. These products are all stock designs, that is, there is no appreciable amount of engineering work involved in designing to individual customers' specifications. Hence, engineering personnel is not so greatly affected by production activities. Undoubtedly, if the figures were available, it could be shown that product development activity exclusive of routine engineering work, in this field at least, is as great as ever and in many instances more so. Indeed, this is corroborated by the fact that 330 out of the 430 companies included in this report are actively engaged in the development of new products in their present line, while 128 of these companies are perfecting new products in a new line.

The general character of the product development activities for all of the companies included in this summary is shown by the following tabulation:

GENERAL CHARACTER OF PRODUCT DEVELOPMENT

	Companies
Higher price class	89
Lower price class	212
Reduced cost of manufacturing	221
Greater number of styles	154
Designs modified to increase the range of operation or use of the product	189

These figures go hand in hand with the design factors that are being emphasized in order to bring about the desired aims in the product development program.

DESIGN FACTORS EMPHASIZED

	Companies
Higher speeds	170
Larger and heavier units	78
More automatic operation	147
Greater precision in use	158
Decreased power consumption	120
Improved gearing	101
Better electrical control	136
Better springs	29
Devices to minimize vibration	137
Better lubrication	181
Adoption of corrosion-resisting materials	207
Improved lock washers and locking devices	116
Closer manufacturing tolerances	156
More easily replaceable units	189
Restyling to give new form	179
Better surface finish	149
Improved color schemes	47
Materials adopted for improved appearance	141

In the two above tables some of the items may require explanation. Thus, 212 companies are aiming for a lower price class while only 89 are designing for a higher price class. Yet, at the same time, 207 companies are redesigning for further adoption of corrosion-resisting materials, 116 are going after improved lock washers and locking devices to prevent parts loosening from vibration, 137 are emphasizing the minimizing of noise and vibration and are adopting materials and units to attain that end. Improved gearing is being stressed by 101 companies, while 136 seek to better their electrical controls. Appearance is well recognized as one of the controlling factors in the salability of the products, and 149 companies are endeavoring to add sales appeal through the medium of improved surface finish; at the same time, 141 companies are emphasizing the adoption of material that will give improved appearance.

Most of the above items involve some increase in cost, yet 221 companies are reported to be seeking lower manufacturing costs, this figure being compatible with that of 212 companies aiming for a lower price class. It is evident from the above that the term "lower price class" should not be confused with the term "lower quality." It is apparent from

the above tabulation that the principal aim of practically all manufacturers is to incorporate the best materials and parts available for the service required. Manufacturers evidently feel convinced that the best must be used if the product is to be generally salable, purchasers demanding the best and latest improvements that science and industry can offer. At the same time, manufacturers are striving in every way to cut manufacturing costs in order to avoid going into a higher price class, or better still, to be able to offer super-quality goods in a lower price range. This is strikingly shown by the following tabulation:

MATERIALS, CONSTRUCTIONS, PARTS AND FINISHES WHOSE ADOPTION IS BEING CONTEMPLATED

(Based on 170 Companies)

Materials

	Companies
Alloy cast iron	24
Alloy steels	16
Malleable iron	12
Stainless steels	36
Aluminum or its alloys	32
Copper-nickel alloys	5
Magnesium alloys	23
Copper, brass and bronze	27
Fibre	10
Rubber	15
Cork	10
Porcelain	7
Wood, plywood, pressed wood, etc	4

Construction

Steel castings	11
Forgings	17
Die-castings, (zinc or aluminum alloys)	26
Pressed metal parts	21
Rolled, drawn, or extruded shapes	23
Welded construction	20
Molded parts	17

Parts and Units

Ball or roller bearings	17
Electric motor drive	11
Gasoline engine drive	4
Clutches	8
Flexible couplings	8
Universal joints	6
V-belts	16
Silent chain or roller chains	14
Flexible shafting	10
Speed reducers	10
Variable-speed transmissions	11
Pumps and controls for hydraulic operation	17
Self-lubricating bearings	12
Gun-type lubrication	7
Central lubricating system	18
Oil filters	12
Electric heating units	11
Auxiliary control apparatus (indicating, recording, regulating, timing, counting, etc.)	15
Lacquer, varnish, or Japan finishes	12
Porcelain enamel finish	7
Chromium, cadmium, nickel, and other plating	48

It will be noticed that in the above table, stainless steel leads in the number of companies who are contemplating its adoption, with aluminum or its alloys a close second. It is, of course, impossible to judge the number of instances in which aluminum or its alloys is being adopted for its corrosion-resisting properties as well as for its light weight. However, judging from the fact that the adoption of corrosion-resistant materials is the design factor that is being emphasized by the greatest number of companies, it might be assumed that a considerable number of the instances wherein the adoption of aluminum or its alloys is being contemplated is dictated by its corrosion-resisting properties. It should also be stated that the attention being given to porcelain-enamel finish, as indicated in the last of the above tabulations, is also a reflection of the great attention that is being given to corrosion-resistance. However, the great number of instances in which the adoption of magnesium alloys is being stressed is because of its extreme lightness.

Rubber and cork, both of which materials have come into wide general use within the past several years, are being considered for further adoption by 15 and 10 companies respectively. These figures, however, are somewhat misleading as more than 25 companies have reported the recent adoption of these materials, mainly for the purpose of isolating vibration.

Apparently, the experiences of many engineers have been that the adoption of alloy cast iron results in true economy, as indicated by the 24 companies that are contemplating this material. This goes hand in hand with the further adoption of alloy steels.

Considering the types of construction, die-castings head the list for contemplated future adoption, undoubtedly largely because of the fact that they not only lend themselves to economical construction but also present a pleasing appearance both in form and surface finish, advantages that can also be cited for molded plastics. Such type of construction also lends itself to making the unit parts more easily replaceable, a factor which is receiving the second greatest attention.

With reference to the great amount of attention that is being given to rolled, drawn, or extruded shapes, and pressed metal parts, this goes hand in hand with the importance that is being attached to welded construction plus good appearance. The prime necessity of cutting costs to a minimum has undoubtedly, in many instances, forced the adoption of welded construction, which in turn is calling forth a greater use of pressed metal parts and rolled, drawn, or extruded shapes in order that the resultant products shall have a pleasing form.

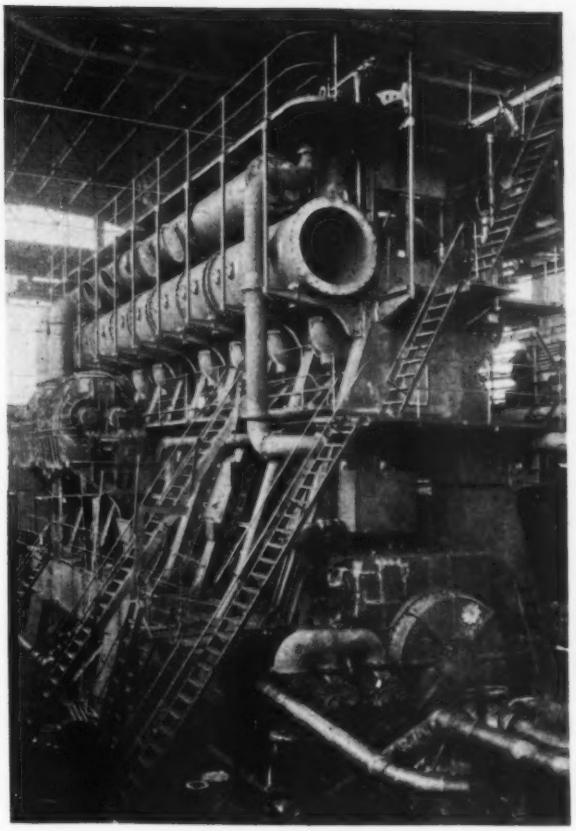
In the above tabulation of parts and units whose adoption is being contemplated, the great attention that is being given to general improvement in product design is further emphasized. Thus, although ball and roller bearings are in general use, yet 17 companies are reported as giving their attention to the further adoption of these units. A similar situation exists with reference to electric motors, speed reducers, V-belts, chain drives, and a number of other items.

Of particular significance is the attention that is being given to lubrication, the above tabulation of contemplated adoption of parts and units indicating that more than one-third of the companies are emphasizing this item. With reference to self-lubricating bearings, these are receiving attention mainly from manufacturers of textile machinery and light machines, such as home and business equipment.

Undoubtedly of greatest interest with reference to lubrication is the large number of companies who are contemplating the adoption of central lubricating systems. This is a further reflection of the tremendous effort that is made in the development of super-quality products, particularly machines that will operate and can be maintained with a minimum of attention. This last is further emphasized by the fact that 12 companies are contemplating oil filters as an integral part of their products.

It is not surprising that the various types of platings head the list of finishes whose adoption is being contemplated. This is a reflection of the attention that is being given to improved surface finish, in addition to which plating undoubtedly is being considered because of the corrosion-resisting feature. Similarly, lacquer, varnishes and japans are being considered not only for the improved surface finish and surface protection, but also because of the desire for improved color schemes.

PRODUCT DEVELOPMENTS



With a rating of 22,500 b.hp., cylinder diameters of 33 in., length, 65 ft., and height, 35 ft., this 8-cylinder Danish diesel is the world's largest

▸ World's Largest Diesel

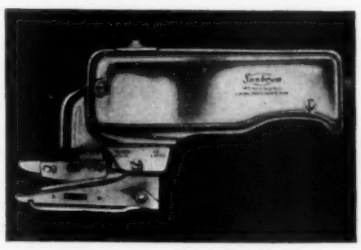
Undoubtedly the world's largest diesel engine is now being erected in the Copenhagen, Denmark, Power Station. Designed by the engineers of Burmeister & Wain, this 22,500-b.hp., 8-cylinder unit may be said to dwarf the 7,000-b.hp. diesels at Vernon, Calif., which are America's largest. The new engine, which is double-acting, two-stroke-cycle, but which differs essentially in its construction from other diesel motors of this class, has a guaranteed fuel consumption of 0.55 lb. per kw.-hr. at the normal load of 15,000 kw. Maximum efficiency is at 12,500 kw., where the consumption is guaranteed not to exceed 0.53 lb. per kw.-hr.

The scavenging ports are at the centers of the cylinder sides, while exhaust gases are discharged through piston plug valves at the top and annular valves about the piston rods at the bottom of the cylinders. Addition of exhaust slide valves naturally complicates the design. The upper and lower valves move together, being connected by beams at top and bottom and vertical rods at each side. Drive is from the crankshaft, which is coupled to an auxiliary shaft by means of a chain. This latter drives the exhaust valves through eccentric rods. The entire drive is inclosed within the crank chamber.

The engine is of the solid-injection type, fuel being injected under a pressure of 5,000 to 6,000 lb. per sq.in. through atomizing valves, of which there are three at the top and three at the bottom of each cylinder. The two fuel pumps for each cylinder are driven from a camshaft which runs horizontally along the front of the engine and is driven by chain from the crankshaft.

An element of the engine without which it could not have been satisfactorily constructed for power-plant purposes is an oscillation damper. It consists of a flywheel housing capable of turning on a sleeve keyed to the crankshaft. Two spiral springs attached to the sleeve cause the flywheel housing to rotate. In the sleeve are eight hydraulic cylinders supplied with lubricating oil through a distributor. This distributor closes the oil inlet a dozen times each revolution, so that the flywheel housing is disconnected every five seconds from the shaft. Dangerous oscillations at critical speeds of rotation are thereby avoided.

Both the upper and the lower cylinder covers are of cast steel, while the center portion of the piston is also of steel. Cylinder liners, in two sections, are of iron. The eight cylinders have diameters of 840 mm. (33 in.) and piston stroke is 1,500 mm. (59 in.); speed is 115 r.p.m. This cylinder diameter is probably the largest thus far used in diesel engine construction, and even in their proposals for certain engines of double the output, the builders recommend additional cylinders rather than increased cylinder bores. The overall length of the engine is approximately 65 ft.; the height is 35 ft.



The handpiece of the Sunbeam electric scissors is shaped to fit the hand, and the blades, which are operated electromagnetically, are placed at a distance and in a position where there is absolutely no danger of the operator cutting himself

▸ Gas Bottles Replace Weighted Accumulators

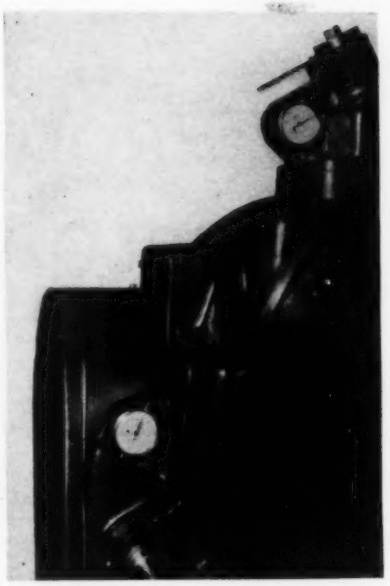
Air bottles to replace weighted accumulators for the storage of energy in hydraulic power systems are not unknown in this country, and they have been somewhat extensively used in Germany. In such installations, however, it is necessary that an air compressor be supplied to maintain the air supply. Air is absorbed by water, and the necessary elastic fluid is thus lost. Inert gas bottles containing suitable gases, such as nitrogen or helium, have been used to a limited extent in Germany and very little, if at all, in this country. These bottles are partially filled with gas.

Once introduced into the system the gas remains indefinitely as it is so chosen as to be practically insoluble in the liquid used for the system. It is not subject to loss due to accidental pressure release because a solenoid-operated valve under these conditions isolates the bottle from the remainder of the system.

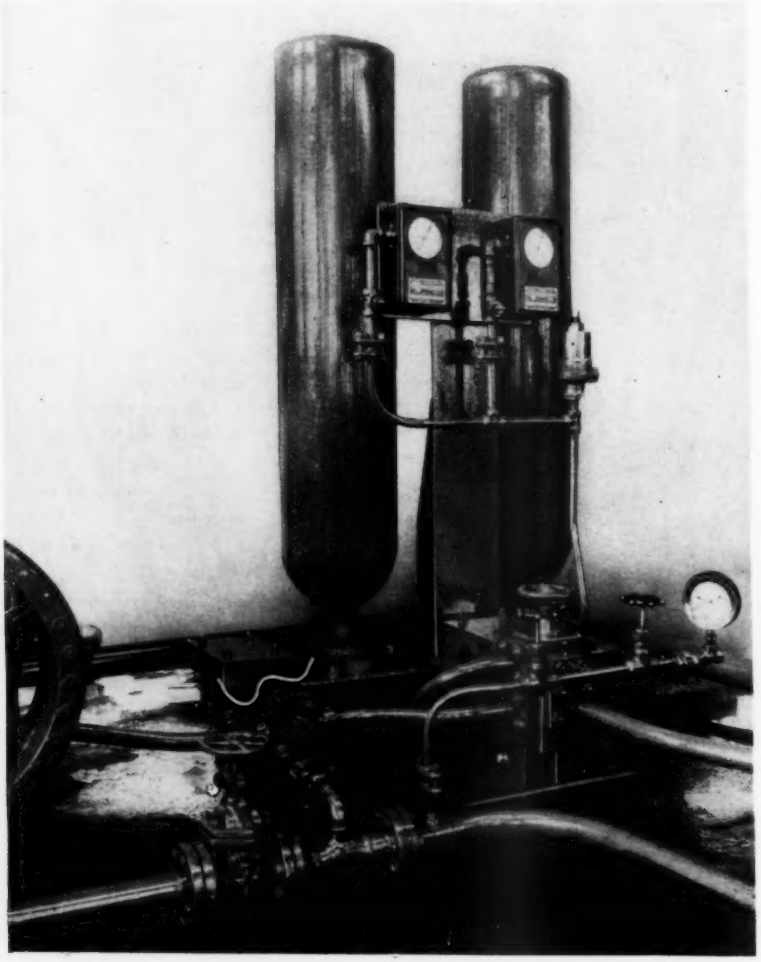
While the use of inert gas is new, and therefore interesting, features of greatest interest and value center around the controls which the engineers of Baldwin-Southwark Corporation have applied to the system. The inert gas being expensive, it is necessary that provision be made against loss. It is also necessary that arrangements be made that such gas does not escape into the hydraulic press system; air or other gas in a hydraulic system, if present in any appreciable quantity, is very undesirable. There must also be controls for upper and lower normal pressure range limits. In addition, there should be a control of some nature which would prevent the hydraulic pump from producing a pressure dangerous to the parts of the system. This indicates a necessity for four control points.

Consequently, two pressure gages with electric contacts are necessary. The first of these serves to energize through a relay a solenoid which in turn permits a check valve to close and thereby to isolate the hydro-gas accumulators from the hydraulic system. This does not, however, isolate the pump, and it is possible for the press to continue in operation using liquid under pressure directly therefrom. This, however, is an unusual condition and one which would not be tolerated longer than necessary to make whatever corrections are necessary in the system.

The next contact in the series of increasing pressures is that which closes a bypass valve in the pump discharge line and permits the pump to supply liquid to the hydro-gas accumulator and thereby increase the pressure. The next in the range opens the same bypass valve and prevents an increase in pressure by bypassing the pump discharge to a supply tank. In case of failure somewhere in the system, the fourth contact, and at a somewhat higher pressure, serves to operate the pump motor control and to disconnect the motor circuit from the electric power supply circuit and instantly stops the motor.



In the Fellows three-lap type gear lapping machine adapted to external, spur, helical and herringbone gears, the designers have incorporated two 0.0001-in. dial indicators to facilitate setting the two upper lap spindles for correcting distorted helical teeth



Utilizing an inert gas such as helium or nitrogen this "hydro-gas" accumulator designed to replace weighted accumulators in hydraulic pressure systems

In restarting the motor under circumstances such as these, there is inherent in the motor starting circuit a relay which operates the bypass valve in the discharge line from the pump for a short time until the pump has had an opportunity to come up to speed. This is a time delay relay, which, at the end of a predetermined period, permits the bypass valve to close, and the system is ready for service. There are, in addition of course, the usual spring-loaded safety valves as an added protection to the system.

With a supply tank, it is possible to arrange for a low-pressure filling system in addition to the high-pressure press-operating system. This tank after having been supplied with water to a predetermined height is filled with an inert gas at low pressure, and this liquid is then used for rapid filling of the cylinder and for the advancement of the ram to a point where the

high pressure is necessary. This transfer from low to high pressure can be made by means of special valves, automatically, or it can be handled manually as might be best in particular installations.

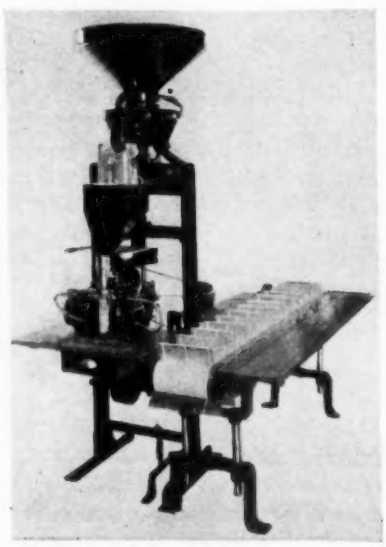
▸ New Material Uses

Through the adoption of Dowmetal, a magnesium alloy, the designers of a trailer for over-the-road delivery of motor cars have achieved a weight of 2,850 lb. as against 5,700 lb. for a steel trailer of equal capacity. With floors and side rails of magnesium alloy, the trailer becomes a general freight hauler and weighs 4,180 lb. as against 8,700 lb. for a wooden-floored steel trailer. Ramp, loading device and rear skids are surfaced with Dowmetal subway grating which provides a non-skid surface, wet or dry. The skids weigh but 60 lb. each.

According to Dow Chemical Co., magnesium alloys are also being designed into foundry flasks, patterns and core boxes, and into "bread peels" to take the place of wooden peels in bakeries. Chrome-phosphate and chrome-nickel treatments as paint bases greatly improve the protection afforded by paints, varnishes and lacquers on magnesium.

Drop forged stainless steel has been adopted by the engineers of Worthington Pump and Machinery Corp., for valve service in their new lines of horizontal duplex steam pumps for petroleum, water and chemical service.

Chromium replaces tin for the interior surfaces of a new line of Rome copperware for the kitchen. Rubbing tests indicate that the chromium has a life of some 6,000 rubs as against 50 for tin.



The five functions of weighing, screening, bag opening, conveying and closing are incorporated in this one machine for the packaging of food products

▸ Five Units in One

In a single unit for packaging food products, the engineers of the Triangle Package Machinery Co., have combined five units: an automatic weigher, a cellophane bag opener, a screen, a paddle conveyor and a bag closer. With this equipment, an operator feeds the bags in the "flat" to the bag opener, which pulls the sides apart by vacuum. The weighing machine delivers a constant feed of material to fill the bags and the conveyor carries the packages to the closing operation.

Designed especially for handling candies, nut meats, and similar frail products, the weigher is so constructed that it screens small pieces and surplus sugar from the weighed loads automatically. The equipment is said to be easily and quickly adjustable for different sizes of packages, varying from 4 to 16 oz. in weight, and operates at a speed of 15 to 25 packagings per min.

Two views of the Remler microphone, one complete with floor-stand, and the other knocked down to show the molded head parts and the condenser

▸ Self-Insulated Condenser Microphone

A new condenser microphone, designed to meet all professional requirements and embodying unusual construction features, will shortly be announced by the Remler Co. Notable is the fact that almost the entire microphone is molded of insulating plastic material, the first time so many molded parts have been incorporated in microphone design. These lighten the assembly and reduce the pre-amplifier housing in diameter.

The new mike has two stages of pre-amplification, and may be entirely a.c. operated with power supply unit, giving an essentially flat response from 40 to 10,000 cycles per second. Other features include an imbedded copper shield in the molded plastic head-housing to eliminate interference, an automatic bias, and a specially high permeability transformer core. The design of the pre-amplification unit also departs from the conventional, in its pin-and-socket design, which makes replacement and servicing simple and fool-proof. All of the other exposed pieces except the flexible grill over the diaphragm are molded of Durez, including the head housing and the suspension converter plug, which instantly enables the user to turn the mike into an overhead suspension type.

Mechanisms for

GEORGE A. SWARTZ

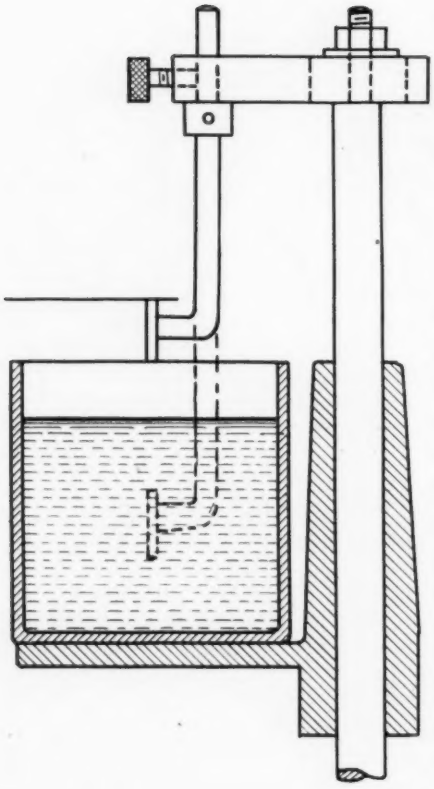


Fig. 1—Direct glue dabbers such as this are inexpensive and simple, but can be used only when it is permissible for the quantity of glue to be applied to vary and when the application is to be made in strips or dots. The applicator, of any desired shape, is held on the end of a bent rod, all parts that immerse in the glue being so shaped as to drain freely and not to splash when entering the glue. A collar on the rod serves as a stop to enable quick resetting after its removal for cleaning, while the linkage holding the applicator permits adjustment over a wide range of positions. The glue pot can be removed freely and usually requires no securing device other than means to prevent it from shifting.

In designing these mechanisms, the device must allow only a minimum of variation in the consistency of the glue at the point of application. Therefore the glue pot must be amply large so that evaporation of the solvent will affect the glue consistency but slightly. Even in transferring the glue, it should be exposed as little as possible to the atmosphere. In the device shown here, its directness of application and the simplicity of the parts in contact with the glue give it a high rating for continuous good performance.

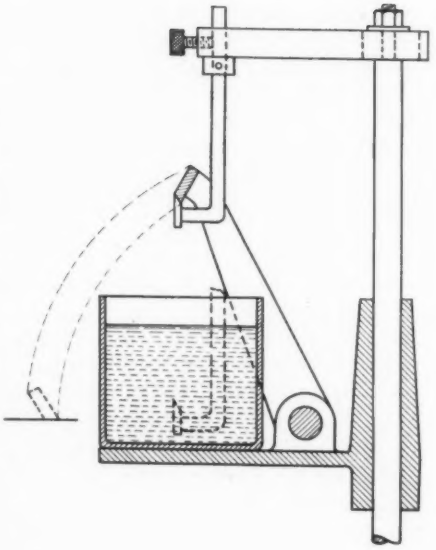


Fig. 2—Example of an indirect type of gluing mechanism, similar in design to the direct type except for the addition of the transfer member. This makes it possible to apply glue to top surfaces and also to control in a certain measure the thickness of the layer of glue applied. This mechanism is also of the type that applies strips or dots rather than films. In all of these designs simplicity is of greatest importance in order that the device will be easy to keep clean, lubricated and adjusted.

With reference to all types of gluing mechanisms, the practice of exposing the glue to the atmosphere after it has been applied and before the closing or uniting operation, in order to partially evaporate the solvent and thus make the glue more tacky, must be avoided. Such a practice usually is a serious source of troubles as many variable factors such as time, temperature and atmospheric conditions enter in and will seriously affect the efficiency of the machine unless compensation can be made for the variation in these factors and the time element can be maintained constant by uninterrupted operation of the machine.

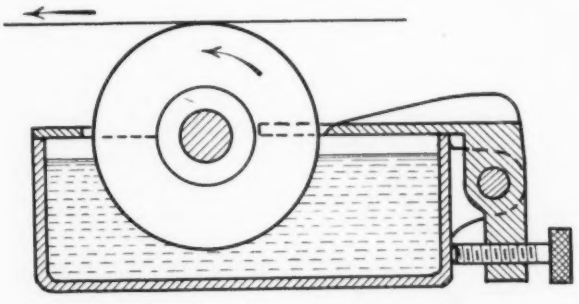


Fig. 3—Film applicators are used much more extensively than those applying dabs, because they permit the application of a uniform film of glue of any selected thickness. A direct acting type of this class of device is shown here. The material receiving the application runs in contact with the wheel which dips in the glue, the application being made to the under surface. Best results are ob-

Applying Glue

Gluing mechanisms, one of the important units in many automatic packaging and similar machines, must deposit the proper amount of glue in the best condition to perform its work. One type applies a dab, another applies a film, each may operate directly or indirectly

tained when the wheel runs at the same surface speed as the material passing over it. In this class of glue applicators greatest attention must be given to the design of the trimmer blade. This blade must be adjustable, but it should be so constructed that in making the adjustment the blade will keep its proper relation to the wheel.

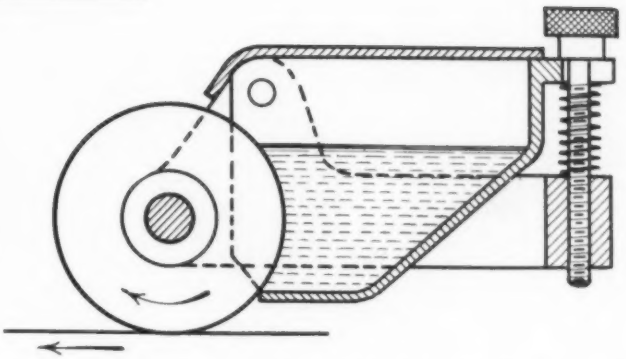


Fig. 5—In this design of direct applicator, the film of glue is applied to the upper surface of the sheet. To keep the exact relation between the trimmer blade and wheel, there must be a complete elimination of lost motion. If a means for locking the trimmer blade in position is provided it should be so designed that the act of locking will not disturb the setting. It should also be possible to remove the parts for cleaning without disturbing the setting. The drive of the glue wheel should be positive to insure the proper speed. A belt drive is not to be recommended.

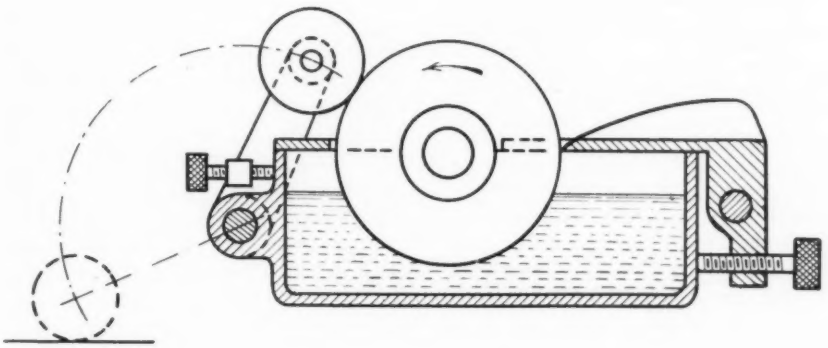


Fig. 4—In the indirect types of film applicators, a transfer wheel receives glue from the main wheel and transfers it to the point of application. The clearance between the transfer wheel and the main wheel is usually made adjustable. On machines that must be stopped frequently the drive to the glue wheels should be independent of the drive for the main machine so that the glue wheels can be kept revolving when the machine is stopped, thus preventing the glue from drying on the surface of the wheels.

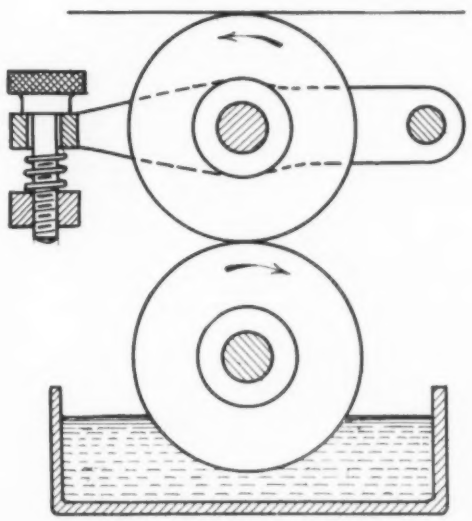
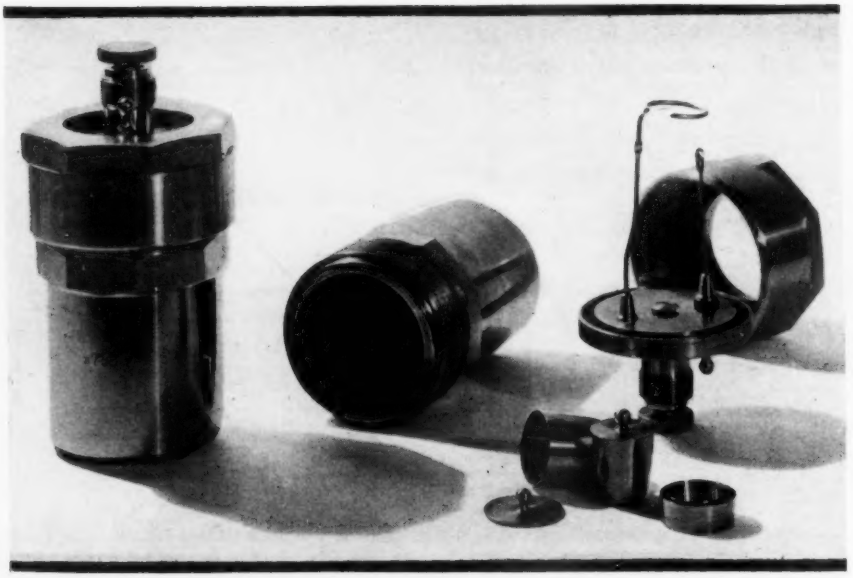


Fig. 6—A type of trimming mechanism that is much in use in sheet mounting machines and gumming machines. This type is easily cleaned and adjusted. When the rollers are long, consideration should be given to the deflection in the center of the rollers due to the pressure exerted in the squeezing out of the glue. This deflection, unless compensated for, will result in a thicker film of glue in the center of the rollers than at the ends. This is usually compensated for by making the glue roller larger in diameter in the center than at the ends. This device has no trimmer blade but thickness of glue film is regulated by adjusting the gap between the rollers.

ILLIUM

W. D. STALEY
Manager, Burgess-Parr Company



The search for a suitable material for calorimeter bombs led to the development of Illium. From left to right: bomb assembly complete, bomb body, cover and clamping ring together with laboratory crucibles and covers

It has been found that the chemical and physical properties of certain alloys in the nickel-chromium-copper ternary group are dependent to a great degree upon the other elements present. Although these other elements may be present only in small amounts, their effect is apparent in the degree of corrosion-resistance, machinability and the metallic soundness of the resultant alloy.

To obtain unusual corrosion-resisting qualities, it is often necessary for the metallurgist to make some sacrifice in physical properties. This is why some corroson-resisting alloys cannot be rolled or forged, why they are available only in the form of castings. Such alloys, however, have a wide range of applications as long as desirable machining characteristics are maintained. A case in point is Illium.

In 1916, the Burgess-Parr Company was engaged in the manufacture of calorimeters. Now a calorimeter bomb is somewhat different from those of the pineapple variety. Where the latter are expected to burst with resultant mayhem, a calorimeter bomb should remain intact after ignition so that the heat of combustion can be accurately measured. In addition to this task of holding hot gases under enormous pressure, a calorimeter bomb must withstand the corrosive action of such materials as nitric and sulphuric acid generated in the course of the combustion. A very dense, tough, corrosion-resisting metal is required. It must cast soundly and be machinable to precise dimensions.

With these requirements in mind, the producer searched existing markets for suitable metals, and finally decided to develop a special alloy for the purpose. Research and experiment led to Illium, a non-ferrous alloy of the nickel-chromium-copper ternary system. This alloy also contains small quantities of molybdenum, tungsten, silicon, carbon, manganese and iron, but not enough of the latter to classify it as a ferrous alloy in the commonly accepted sense.

The new alloy lived up to expectations. In fact, the second bomb made from it is still in service after 15 years of use and more than 50,000 calorimetric determinations—another way of saying "confined explosions."

One of the characteristics of Illium is that it is resistant to many widely differing reagents. As shown in the accompanying table, most acids, salts, gases and organic substances affect it only slightly, if at all. Moreover, it is unusually resistant to many of the combinations, mixtures and impurities found in industrial practice. With any of the reagents shown in the table, the penetration is so slight that it is claimed the alloy may be used with economy in plant scale operations. It might be well, however, to state that the resistance of Illium to strong or hot hydrochloric acid, wet chlorine gas, or substances which in reaction release chlorine, is not sufficient to warrant commercial use.

Some time ago a machined rod of Illium, together with similar samples of copper, molybdenum, steel and brass, was placed in a salt muck bed in a Florida swamp for three months' test. Such a test is regarded as severe because the samples are subjected to action of the tides, and therefore are being alternately exposed to oxidation from air and corrosion from sea water, to say nothing of the mechanical wear of the water and particles it might contain. At the end of the test, the Illium sample was weighed on a chemical balance, and showed no perceptible difference from its weight at the beginning of the test. Each of the other samples lost weight (milligrams per sq.cm.) as follows: Steel, 22.43; brass, 1.59; nickel, 2.4; copper, 1.19, and molybdenum, 3.62.

A second Illium rod had a copper wire wrapped around it to accelerate corrosion, if possible, by a form of electrolysis. This test was for a period of three years. At the end of this time the Illium rod still retained its original polish. The copper wire was almost entirely decomposed. These results illustrate clearly the fact that while elements such as nickel, copper or molybdenum may show decided corrosion under certain conditions, an alloy containing these same elements may be immune under the same circumstances.

In a recent series of four laboratory tests, Illium samples having a surface of 10 sq.cm. showed the following results: (1) In 25 per cent sulphuric acid for 171 days at a temperature of 80 to 100 deg. F., the

List of Reagents With Which Illium May Be Used

Acids	Salts	Organic Substances	Miscellaneous
Acetic*	Ammonium chloride	Acid mine water	Bleaching powder†
Butyric	Ammonium sulphate	Apple vinegar	Bromine solution
Citric*	containing H_2SO_4	Carbolic acid	Carbonated water
Formic	Copper sulphate	Formaldehyde	Hydrogen sulphide‡
Hydrocyanic	Ferric chloride	Fruit juices	Sulphur dioxide†
Lactic*	Mercuric chloride	Malt vinegar	
Nitric*	Potassium alum		
Oleic*	Silver nitrate		
Oxalic*	Sodium chloride†		
Phosphoric*	Sodium hydroxide		
Picric	Sodium hypochlorite		
Sulphuric*	Sodium nitrite		

* All strengths and all temperatures.
† At ordinary temperatures.
‡ Gaseous or in solution.

sample showed a loss of 0.0005 grams per sq.cm. area; (2) In 60 per cent sulphuric acid for 53 days at a temperature of 85 to 100 deg. F., the sample lost 0.0004 grams per sq.cm. area; (3) In 25 per cent sulphuric acid at boiling point for three days, the sample lost 0.0063 grams per sq.cm. area; (4) In 25 per cent nitric acid for 69 days at 85 to 100 deg. F., the sample lost 0.0003 grams per sq.cm. area.

One of the first commercial uses for Illium outside the field of scientific instruments was in pumps for handling mine waters. Where certain other special acid-resisting alloys had a life of only a few weeks in pumping this water which contained varying percentages of mixed sulphuric and sulphurous acids, the Illium castings showed no perceptible corrosion or wear after double the usual test. Those same castings, in the form of housings and impellers for centrifugal pumps, have been in service since 1922. A recent inspection showed the parts still in first-class condition.

In one of the leading organic laboratories, one process required the stirring of a strong solution of persulphuric acid at the extremely high speed of 20,000 r.p.m. Because unusually severe and rapid corrosion was expected, the first steel stirring spindle tried was inspected after 5 min. of use. The rotor blades had been reduced to knife edges.

Next a gold-plated spindle was tried, and because corrosion was not expected, the spindle was not examined until the run was completed—about 30 min. At the high speed of operation, the acid forced its way through the plating into contact with the steel, ruining the spindle. The third spindle, made of Illium, operated more than 12 hr. without corrosion. The same spindle has also been used more than 40 hr. in acetic acid of concentration varying from 50 per cent to 100 per cent.

Obviously, comparative inertness to chemical action is not the only factor to be considered in selecting a material for corrosion-resistant service. As shown by the following list of physical characteristics, Illium is strong, tough and moderately hard in addition to being corrosion-resistant:

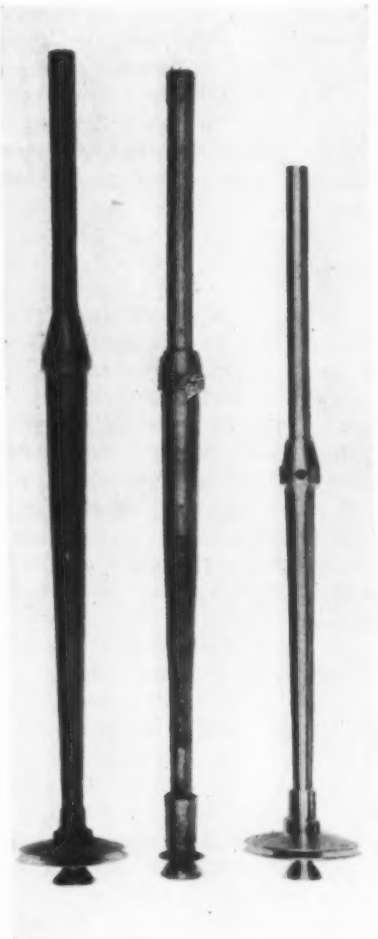
Tensile strength	60,000 lb. per sq.in.
Elastic limit	50,000 lb. per sq.in.
Hardness—Brinell	170-200
Hardness—Rockwell "B"	87-93
Melting point	1,300 deg. C. (2,372 deg. F.)
Specific gravity	8.3
Weight per cu.in.	0.3 lb.
Specific heat	0.105 cal. per deg.
Coefficient of expansion per deg. C. (Range 20-300 deg. C.)	0.0000135
Electrical resistance	121.9 microhms cm.[3]
Contraction in casting	5/16 in. per ft.
Machinability	Slightly harder than cast steel

Illium machines readily. It may be turned, planed, milled, bored, threaded or tapped without difficulty, following the same general procedure that applies to cast steel. The advantage of machinability in an alloy of this kind should not be understated. Almost every corrosion-resisting part requires finish to a fairly close dimension either because it is a rotating or moving part, or because close fit must be maintained to prevent leakage.

Another useful characteristic of this alloy is that it welds readily to itself or to other metals by either the acetylene or electric arc method. If Illium welding rod is used, the structure of the weld is practically identical with that of the adjacent casting.

In appearance, polished Illium has a bright, slightly bluish surface somewhat resembling chromium. It may also be of interest to note that it can be plated with such metals as copper, nickel or chromium. However, since the Illium itself has a high, non-tarnishing lustre when polished, little plating has ever been done.

It should be said that Illium is available at present only in the form of castings made to customers' specifications in the producer's foundry. These castings range from delicate parts weighing less than 1 oz. to pieces of 200 lb. or more. Castings with walls as thin as $\frac{1}{16}$ in. have been produced. Properly handled, Illium lends itself well to precise work of this nature, maintaining uniform soundness and density with comparative freedom from porosity. Though the principal industrial uses are in the process and mining industries, its numerous advantages offer a wide field of uses to the product engineer.



Left: rotor blades of steel stirring spindle reduced to knife edges after 5 minutes at 20,000 r.p.m. in strong solution of persulphuric acid. Center: similar gold-plated steel spindle after 30 minutes at same speed in same solution. Right: cast Illium spindle after 12 hours, at same speed, same solution

Inertia Forces in Cam Mechanisms—II

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Arcs of circles, parabolic and harmonic curves are considered in further detail in this second article which completes the author's analysis of cam curves with respect to the acceleration forces involved

On cylindrical cams arcs of circles are frequently used in the development to take care of the shock at the ends of the motion. Sometimes two arcs may be used for the entire rise, while in others like Fig. 5, they are combined with a considerable section of constant velocity motion. In this figure the follower is to move a distance D while the surface of the cylindrical cam moves through a linear distance A or KT where K is the linear velocity of the surface of the cam. The radius of the arc to give the ease-off B is R. The acceleration a of the follower at any point y where the radius makes an angle of $\propto$ with its original position is given by the following expression which is readily derived from the equation for an arc of a circle:

$$a = \frac{K^2}{R \cos^3 \alpha}$$

This equation shows that the acceleration has its minimum value at the initial position where α is zero and reaches a maximum when this angle equals the maximum slope θ. When θ is 30 deg. the acceleration is about 52 per cent above the initial value, while on reaching 45 deg. it is 180 per cent larger. If θ goes as high as 50 deg. the value of the acceleration goes up to 3.7 times the initial amount.

This rapid increase in acceleration indicates that it is not advisable to use arcs of circles for ease-off at the ends of the stroke if the slope of the cam curve is at all large. Thirty-five deg. is a good limiting value as here the maximum acceleration is about 80 per cent greater than the initial value. An added disadvantage of this type of ease-off is that the maximum velocity of the follower is always greater than with either constant acceleration or harmonic curves.

If a slide is to move a given space in a given number of degrees of cam rotation and a certain per cent of the stroke is allowed at each end for ease-off, lower values of velocity and acceleration will always be secured with the parabolic curve than with an arc of a circle. A harmonic curve will give a still lower value of the maximum velocity while the acceleration will fall between the parabolic and arc of circle curves with the larger values of the slope.

When an ease-off is desired at the ends of a straight line advance, it can easily be taken care of using either parabolic or harmonic accelerations. Referring to Fig. 6 a cam is to move its follower a distance D while rotating through the angle A which equals KT. The central part of the motion is to be straight line while the shock at the ends is to be reduced by an ease-off through the distances B and C at the bottom and top of the rise respectively.

If the distance B is laid off below a and C above b, the slope of the resulting line ef will give the velocity during the straight line section of the motion. The time required for acceleration and retardation, T_1 and T_2, can be readily calculated from the geometry of the figure. For instance:

$$T_1 = \frac{2A}{D + A + B}$$

The value of the acceleration is:

$$a = \frac{2B}{T_1^2}$$

The rise for each degree of cam rotation can be calculated by the methods given in an earlier paragraph.

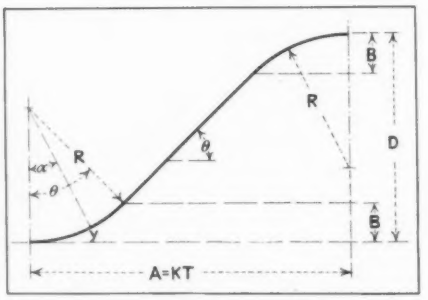


Fig. 5—Cylindrical cam development with arc of circle ease-off at ends of stroke

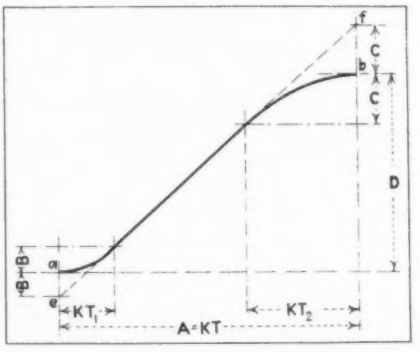


Fig. 6 — Cam development showing parabolic ease-off at ends of straight line motion

If a harmonic ease-off is desired a similar method can be used as shown in Fig. 7. The distances laid off below a and above b are 0.5708 times the ease-off desired. The other figures are readily calculated from the

layout, while the maximum value of the acceleration is

$$a = B\left(\frac{\pi}{2T_1}\right)^2$$

[Editor's Note—*Attention is called to the formula for maximum rate of deceleration given in the last column on page 396, October number, which should read* $R_2\ (\pi/2\ T_2)^2$]

The machining of face cams is greatly simplified if the contours are arcs of circles. This is particularly true if only a few cams are required.

In small cams flat mushroom followers are frequently used. If a round disk mounted as an eccentric moves such a follower in a straight line, the resulting action will be simple harmonic motion with one complete movement equal to twice the eccentricity of the disk. If two different arcs are used for the outward movement, the stroke will be made up of sections of two harmonic motions, one generally being in acceleration and the other retardation. Fig. 8 shows a section of the contour of a face cam which rotates about the center O. The lower part is a dwell of radius R_1. When the follower which reciprocates in the direction OA is in contact at a, it starts an outward movement riding on an arc of radius R_2 which has a center at e. When rotation has progressed through the angle θ_1 the contact is at b which is at the point of tangency of the arc of radius R_2 and that of R_3. From here the follower is retarded as it moves through the angle θ_2 and it finally comes to rest at c where it reaches a dwell of radius R_4.

In an earlier paragraph it was pointed out that in simple harmonic motion the acceleration is a maximum at the end of the stroke and decreases to zero at the center. In this illustration half the stroke would have to equal oe to have the acceleration reach zero, so obviously the rate is not reduced much from the maximum before the retardation section of the stroke is reached. This indicates that conditions of acceleration superior to those of the simple harmonic curve and approaching the parabolic can be attained with a flat follower by using arcs of circles for the cam contour.

The maximum value of harmonic acceleration at the end position is $R\omega^2$ where R is the radius of the describing circle and ω is its angular velocity in radians per sec. In this case the maximum acceleration at the beginning of the outward stroke is $\overline{oe}\omega^2$, while the maximum retardation rate coming at the end of the stroke is $\overline{od}\omega^2$. The two acceleration rates are therefore directly proportional to the distances oe and od. The stroke is equal to $(oe + od - de)$. The distance moved while the velocity is increasing is $oe\ (1 - \cos\theta_1)$, and $od\ (1 - \cos\theta_2)$ while it is decreasing.

For example, let us assume a stroke of $\frac{1}{2}$ in. is desired while the cam rotates 60 deg. and the maximum rate of acceleration outward is to be twice the retardation. Referring to Fig. 8, lines later to become two sides of a triangle are laid off in such a way that the angle of rotation θ or 60 deg. becomes the exterior angle between od and oe extended. Using the facts that the length oe must be twice od to give the rate of acceleration desired,

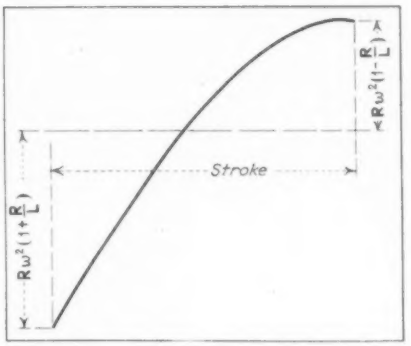


Fig. 9—Acceleration diagram for a crank and connecting rod with a relatively short rod

and that the sum of these two distances minus the length oe will give the stroke, values for the three sides of the triangle ode can be calculated readily. They are 2.822 in., 1.411 in. and 3.733 in. respectively for a $\frac{1}{2}$-in. stroke. The radius R_3 is then chosen at the smallest safe figure from a design standpoint and the radii R_1, R_2 and R_4 are determined by this value and the lengths of the three sides of the triangle.

The acceleration diagram for this cam is plotted on a stroke base in Fig. 8. The scale of the stroke is double size. If any other relation of acceleration at the two ends of the stroke were desired it could be taken care of by proper ratio of the distances od and oe. The chief limitation of this construction is in the maximum length of stroke which can be secured during a small angle of rotation of a small cam. The width required for the mushroom follower may also cause difficulty.

Frequently rollers or points on the ends of reciprocating followers are used with cams whose contours are arcs of circles. This changes the harmonic action of the flat follower to crank and connecting rod motion. An eccentric circular disk acting as a cam would give a simple case of such motion with the eccentricity of the

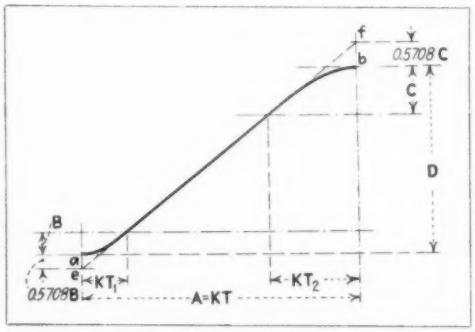
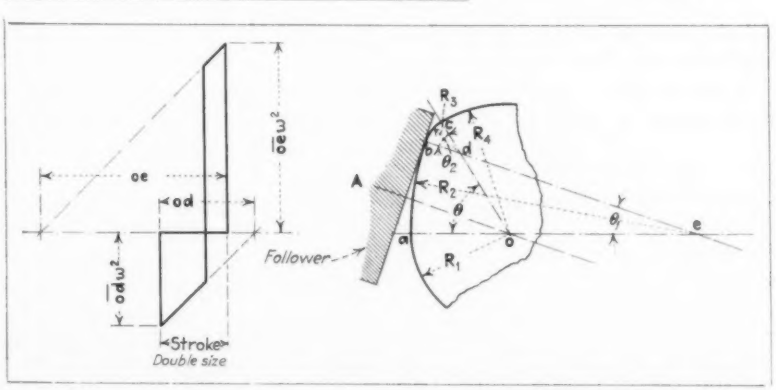


Fig. 7—Straight line motion with harmonic ease-off at the ends

Fig. 8—Below to the left is shown the acceleration diagram plotted on a stroke base for the cam with flat follower, shown to the right



disk for a crank and a connecting rod length equal to the sum of the radii of the disk and of the roller. The acceleration diagram for a relatively short connecting rod would look like Fig. 9, the amount at the outside or "head end" being $R\omega^2(1 + R/L)$ and at the inside or "crank end" $R\omega^2(1 - R/L$ where R is the crank radius, L is connecting rod length and ω is angular velocity of the cam in radians per sec. If the motion is outward to the left the first expression is deceleration and the second acceleration.

If two arcs of circles for the cam contour are used to give one stroke of the follower, short lengths at each end of the diagram in Fig. 9 can be brought together to make the acceler-

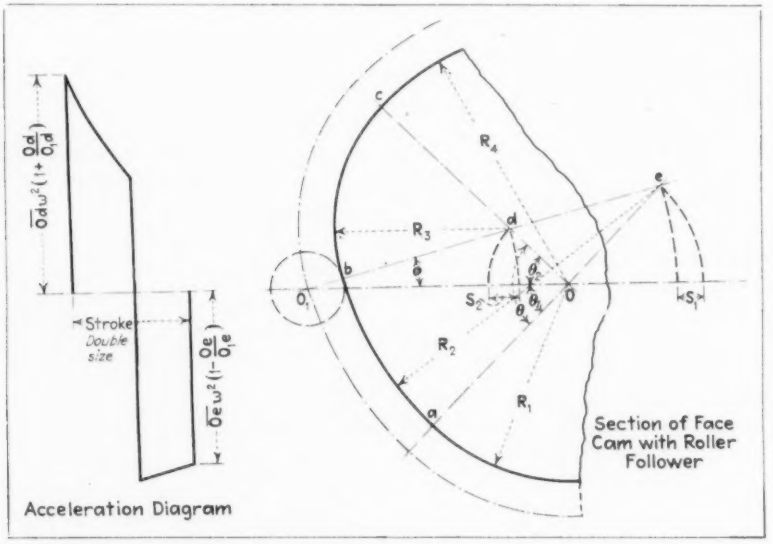


Fig. 10—End accelerations are almost equal, the cam profile being composed of four radii

ation and retardation sections respectively of a new diagram. Also by properly choosing values of R and L for each end of the stroke the inertia forces at the two ends can be made approximately alike. An illustration is given in Fig. 10 where O is the center of the cam and O_1 the center of the roller on the follower which moves radially in the line OO_1. While the roller rides against the arc of radius R_1 there is no motion of the follower. Between a and b it bears against an arc of radius R_2 about the point e, and receives "crank-end" acceleration with a crank radius Oe and a connecting rod length O_1e while the cam rotates through the angle θ_1, and the follower moves the distance S_2 and the cam rotates through the angle θ_2, it slows down with "head end" acceleration due to the crank Od and connecting rod O_1d. If the angles θ_1 and θ_2 are equal the time required for the follower to reach the maximum velocity and the time to slow down to rest are the same, so the acceleration and the retardation rates should not be far apart. The geometry of the figure shows that the stroke equals $(Oe + Od - de)$.

Taking Fig. 10 as an illustration, the follower is to move to the left some chosen distance while the cam rotates counter-clockwise through the angle θ and the interia force during speeding up and slowing down are to be approximately alike. Lay off two lines in the directions Od and Oe so that the exterior angle is θ. The line bisecting θ will then give the relative positions of cam and follower when the latter is changing from acceleration to retardation. Values of Oe and Od which will give the proper stroke, can be assumed and the resulting direction of de will determine the angle of obliquity ϕ and the position of θ_1 at the postion of reversal of acceleration. If this solution is not satisfactory, new values of Oe and Od can be tried. Another method of approach is to assume a value of ϕ and use it in the tangent equation for the solution of triangles to determine the ratio of Oe and Od. The equation for the condition of $\theta_1 = \theta_2$ takes the form

$$\frac{\tan\phi}{\tan\theta/2} = \frac{oe - od}{oe + od}$$

The lengths of the sides to give the proper stroke can then be determined readily. The section of the stroke devoted to acceleration is

$$Od\ (1 - \cos\theta_1) + O_1d\ (1 - \cos\phi)$$

while that taken up by retardation is given by the equation:

$$Oe\ (1 - \cos\theta_2) - O_1e\ (1 - \cos\phi)$$

Fig. 10 also shows the acceleration diagram for the cam contour given. The stroke is drawn double size and the accelerations at the ends are calculated by the equations given earlier. As the values at the point of maximum velocity were determined by methods to be found in books on mechanics of machinery, the details are not indicated. It is interesting to note that the maximum acceleration in this case is only 15 per cent larger than the maximum value of the retardation. If a smaller value of the angle ϕ had been used, the variation would have been still less and even this could be eliminated by a small change in the relative values of θ_1 and θ_2.

This analysis shows that acceleration conditions superior to those of harmonic motion and approaching those of parabolic can be secured using arcs of circles for the contour of a face cam with roller follower. Extension of these methods to the analysis of cams with non-radial reciprocating followers or with followers which oscillate in an arc becomes more of a "cut and try" proposition, but is not difficult if the principles of acceleration analysis are fully understood.

All of this discussion has referred to inertia forces. While these are very important in high speed machinery, it should be remembered that positive work sometimes has to be done by cams and this must also be taken into account in the design. Possibly a slide must be rapidly brought up to a given position and continue at a constant velocity while performing some operation. In closing a chuck the cam may be moving a slide with little resistance except inertia at the beginning of the stroke, then a large amount of force may be required, and finally very little pressure when the levers are moved through the dead center or locking position. There is, therefore, no standard answer for all cam problems but arrival at the best solution in high speed machinery will be helped greatly by a correct understanding of the inertia forces involved and the possible methods for controlling them.

COMMUNICATION AND COMMENT

Some Thoughts on Ball Bearings

H. E. ADAMS

Chief Engineer, The Nash Engineering Company

Troubles with the application of ball bearings to electric motors may be divided broadly into two classifications—quiet operation and lubrication.

A ball bearing is practically precision made throughout, especially where it is made for quiet operation. The tolerances entering into the manufacture of its component parts are held to 0.0001 in. and furthermore, the assembly of the bearing is made from selected parts. The bearing itself, after this careful workmanship, is relatively quiet. But this precision made part when applied to the commercial motor does not always operate without noise, because of improper alignment.

Affecting the alignment of the two ball bearings are the stator, end bell, bearing cartridge and shaft. The stator is generally provided with a rabbeted fit for the end bell, it being essential that this rabbet be square and concentric with the stator bore and that it be of a diameter to snugly engage the corresponding fit of the end bell. Similarly, there is the rabbet fit on the end bell, its cartridge bore, the diameter of the cartridge and the bearing housing in the cartridge, each fit not only being a question of diameter, but concentricity as well. The shaft journals must be concentric with each other and of correct diameter to properly mount the ball bearing without danger of too great a press fit that would tend to preload the ball bearing or the other extreme of too loose a fit that would allow the inner race of the bearing to turn on the shaft.

When it is considered that each of these fits is duplicated, as there are two end bells, cartridges and bearings, and the tolerances in this class are 0.001 to 0.002 in., one realizes the difficulty of assembling such parts and obtaining a reasonable alignment of the two precision made bearings. As a matter of fact, the assembly of a special quiet ball bearing in such combination is commercially extremely difficult, and the general practice is to build the ball bearing itself with loose fits so that it may better adjust itself to the expected slightly misaligned housings of the motor.

It may at first seem a paradox but it is a fact that a bearing built with loose fits is quieter after installation in the commercial motor than is the especially made quiet bearing, the reason being that the bearing with the closer tolerances and tighter fits cannot adjust itself to the motor line-up and runs in a strained position, whereas, with the loose fit bearing the slack of the bearing is taken up by the misalignment of the motor parts. It is, of course, possible by means of carefully selected parts to build up a motor with precision bearings that is reasonably quiet, but the expense of such an assembly is beyond usual commercial possibilities.

Solutions of the Deflection Problem

This problem on the deflection of a hollow hexagonal tapered cantilever beam appeared in the August number. Two answers were published the following month. Here are given three additional examples, the details of the method used being somewhat different in each instance. An additional typical solution that has been selected for publication will appear in the December number.

SOLUTION BY K. A. MAXWELL

In the problem of the deflection of the cantilever beam as given by L. V. Johnson in the August number of *Product Engineering*, the following data was submitted:

Hollow tapered hexagonal section
9/32 in. thick.
7¾ in. across flats at base.
5.4 in. across flats at load point.
22½ ft. from base to load of 100 lb.

The solution of this problem is started with the familiar equation:

$$M = \frac{EId^2y}{dx^2}$$

The relation of E, I and M to the variables x and y must be established. E is constant and will be assumed 29,000,000 lb. per sq.in. M is evidently —P (1 — x) at any section x-distant from O, as can be seen from the figure.

As I varies with x, it must be expressed in terms of x before integrating. From the figure we have:

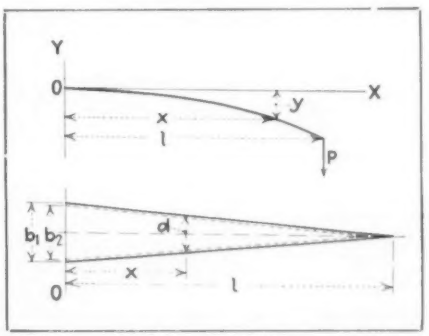
$$\frac{d}{L-x} = \frac{b}{L}$$

$$d = \frac{b}{L}(L-x)$$

To avoid complicated calculations, it will be assumed that both inner and outer sections taper to a common point distant L from O. This will not make an appreciable error.

For a hollow hexagonal section

$$I = 0.0601\,(d^4_1 - d^4_2)$$



The upper diagram indicates the deflection of the beam, while below is shown how *d* can be expressed in term of *x*, *L*, and *b*

Substituting $d = \frac{b}{L}(L-x)$

$$I = \left[\frac{0.0601\,(b^4_1 - b^4_2)\,(L-x)^4}{L^4}\right]$$

Substituting:

$$M = EI\frac{d^2y}{dx^2} = -P(l-x)$$

$$= E\frac{(0.0601)\,(L-x)^4\,(b^4_1 - b^4_2)}{L^4}\qquad\frac{d^2y}{dx^2}$$

Integrating:

$$\frac{0.0601E\,(b^4_1 - b^4_2)\,dy}{PL^4}$$

$$= \int\frac{xdx}{(L-x)^4} - \int\frac{ldx}{(L-x)^4}$$

$$= \frac{L}{3(L-x)^3} - \frac{l}{2(L-x)^2} - \frac{l}{3(L-x)^3} + C_1$$

Since

$$\frac{dy}{dx} = O \text{ when } x = O,\ C_1 = \frac{2l+L}{6L^3}$$

For the second integration:

$$\frac{0.0601E\,(b^4_1 - b^4_2)\,y}{PL^4}$$

$$= \int\frac{Ldx}{3(L-x)^3} - \int\frac{dx}{2(L-x)^2} - \int\frac{ldx}{3(L-x)^3} + \int\frac{(2l+L)dx}{6L^3}$$

$$= \frac{L}{6(L-x)^2} - \frac{1}{2(L-x)} - \frac{l}{6(L-x)^2} - \frac{(2l+L)\,(L-x)}{6L^3} + C_2$$

Since

$$y = O \text{ when } x = O,\qquad C_2 = \frac{l+L}{2L^2}$$

$$\frac{0.0601E\,(b^4_1 - b^4_2)\,y}{PL^4} =$$

$$\frac{L}{6(L-x)^2} - \frac{l}{2(L-x)} - \frac{l}{6(L-x)^2} - \frac{(2l+L)\,(L-x)}{6L^3} + \frac{l+L}{2L^2}$$

When $x = l$,

$$\frac{0.0601E\,(b^4_1 - b^4_2)\,y}{PL^4} = \frac{-l^3}{3(L-l)L^3}$$

$$\text{or } y = \frac{-PL\,l^3}{3\,(0.0601)\,E\,(b^4_1 - b^4_2)\,(L-l)}$$

This formula could be applied to either a hex or conical section.

Let I_B = Moment of inertia at base section.
Let b = Base diameter of cone or distance across flats of hex.

Let d = Top diameter of cone or distance across flats of hex.

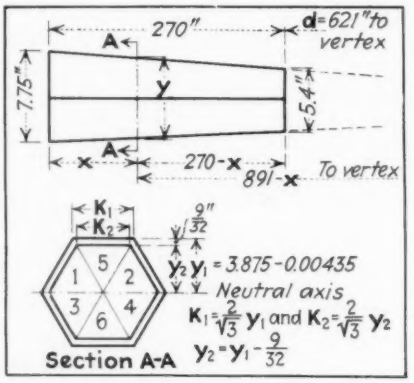
From similar proportions, $L/(L-l) = b/d$.

Hence: $$y = \frac{-Pbl^3}{3dEI_B}$$

In this problem:

$$y = 0.577 \text{ in.}$$

SOLUTION BY DEAN E. HOBART



Referring to the accompanying figure, by similar triangles:

$$\frac{891-x}{y} = \frac{891}{7.75}$$

$$y = 7.75 - 0.0087x$$

$$y_1 = \frac{y}{2} = 3.875 - 0.00435x$$

The moment of inertia of the triangles 1, 2, 3 and 4 about the neutral axis is $\frac{1}{12}\,ky^3$ and of triangles 5 and 6 is $\frac{1}{4}\,ky^3$. There are two triangles in each case, a large one and a small one.

$$I_{AA} = 2\left(\frac{1}{4}k_1 y_1^3\right) + 4\left(\frac{1}{12}k_1 y_1^3\right) - 2\left(\frac{1}{4}k_2 y_2^3\right) - 4\left(\frac{1}{12}k_2 y_2^3\right)$$

Substituting for k_1 and k_2 in terms of y_1 and y_2, and simplifying:

$$I_{AA} = \frac{5}{3\sqrt{3}}y_1^4 - \frac{5}{3\sqrt{3}}y_2^4$$

Substituting $y_2 = y_1 - \frac{9}{32}$

$$I_{AA} = 1.083\,y_1^3 - 0.457\,y_1^2 + 0.0857\,y_1 - 0.00602$$

Substituting for y_1 in terms of x,

$$I_{AA} = 56.276 - 0.197\,k + .00023x^2 - 0.000000089x^3$$

The formula for deflection from Van Den Broek's Elastic Energy Theory is

$$\text{Deflection} = \int\frac{Mp\,Mq\,dx}{EI}$$

where Mp is the moment at any section, as AA, due to unit load at end of beam, and Mq is moment at AA due to applied load at end. In this case 100 lb.

$$\text{Deflection} = \int_0^{270}\frac{(270-x)\ 100\ (270-x)\,dx}{29{,}000{,}000\ \text{I}}$$

$$\text{Deflection} = \frac{100}{29{,}000{,}000}\int_0^{270}\frac{(270-x)^2dx}{\text{I}}$$

Evaluating the integral by Simpsons rule using eleven ordinates and intervals of 27 in. we get:

$$\text{Deflection} = \frac{100\times27\times17{,}047}{29{,}000{,}000\times3} = 0.529 \text{ in.}$$

SOLUTION BY N. M. WICKSTRAND

Derivation of a simple form of formula for the moment or inertia of a thin walled hollow hexagon is:

$$I = 0.06\,(H^4 - h^4)$$

In the above equation H is the distance across the flat of the hexagon on the outside and h is the distance across the flat on the inside. In this problem $H - h = 0.562$ in.

The above equation can now be developed as follows:

$$I = 0.06\,(H-h)\,(H+h)\,(H^2+h^2)$$

$$= .06 \times 0.562\,(2H - 0.562)\,(2H^2 - 1.125\ H + 0.316)$$

$$= 0.06 \times 0.562 \times 4\,(H - 0.281)\,(H^2 - 0.562\ H + 0.158)$$

$$\text{Average } H = (7.75 - 5.4)\,\tfrac{1}{2} = 6.57 \text{ in.}$$

$$\frac{(6.57) - 0.562 \times 6.57 - 0.158}{(6.57) - 0.562 \times 6.57} = \frac{39.47 - 0.158}{39.47} = 1.004$$

$$I = 0.06 \times 0.562 \times 4 \times 1.004\,(H - 0.281)\,(H - 0.562)\,H$$

$$= 0.06 \times 0.562 \times 4 \times 1.004\ H\,(H^2 - 0.843\ H \times 0.158)$$

The last term here (0.158) may also be replaced by another correc-

tion term or coefficient also equal to 1.004. Then

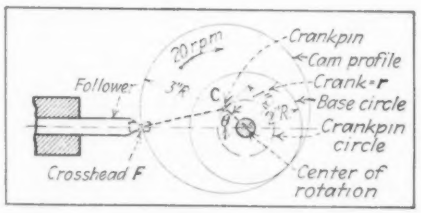
$$I = 0.06 \times 0.562 \times 4 \times (1.004)^2 \; H^2 (H - .843) = .136 \; H^2 (H - .843)$$

It is much easier to solve for the moment of inertia when expressed in this form with the slide rule than in the conventional formula where large errors are apt to be made in obtaining the difference of two numbers raised to the fourth power.

The beam can then be divided into any convenient number of increments, nine for example, and the values of moment of inertia, diameter across flat, and bending moment at mid-section of each increment can be calculated. The curve for bending moment and the product of modulus of elasticity times slope of beam in radians can then be plotted. The maximum deflection can then be obtained, which in this example or problem, using a value of 30,000,000 for the modulus of elasticity, figures out to be 0.514 in. maximum deflection at the end of the beam.

The Cam Problem

With reference to W. W. Johnson's question as to the maximum acceleration of the follower of the cam layout which appeared in the October number, James I. Clower, assistant professor of machine design, Virginia Polytechnic Institute, states that analysis of the mechanism



shows that it is equivalent to the slider-crank mechanism, so commonly employed for converting reciprocating motion to rotary. Therefore, the displacement, velocity and acceleration formulas of the slider-crank may be employed.

The exact acceleration is:

$$r\,\omega^2 \left[\cos\theta + \frac{\cos^4\theta + \cos 2\theta\,(n^2 - 1)}{(n^2 - \sin^2\theta)^{3/2}} \right]$$

where

r = crank radius
w = angular velocity = $2\pi \times$ r.p.m.
θ = crank angle as shown
n = ratio of connecting-rod length to crank length

An approximate formula which is much simpler and sufficiently accurate for most practical purposes is:

$$a = r\,w^2 \left(\cos\theta + \frac{\cos 2\theta}{n} \right)$$

When n is equal to 4, the approximate equation shows a maximum error of about 0.6 per cent of the maximum acceleration. Acceleration is a maximum when

$$\left(\cos\theta + \frac{\cos 2\theta}{n} \right)$$

is a maximum, which is when $\theta = 0$.

Substituting the numerical values in the approximate equation, we have for the maximum acceleration:

$$a = 1\,(2\pi \times 20)^2\,(1 + \tfrac{1}{4}) = 21{,}055 \text{ in./min.}^2$$
$$= 0.487 \text{ ft./sec.}^2$$

Tables and curves for displacement, velocity and acceleration as derived by the exact formulas can be found in an article by J. L. Bogert in *Marine Engineering*, December, 1920.

An exactly similar solution is contributed by M. A. Cook, instructor in mechanical engineering, Rensselaer Polytechnic Institute, who calculated the maximum acceleration as 5,849 in. per sec. per sec., and the acceleration at the other extreme end as minus 2.924 in. per sec. per sec.

Professor John A. Dent, head of the department of mechanical engineering, University of Pittsburgh, also solved the problem in exactly the same manner and added the comment, "The acceleration can also be expressed as a Fourier series as explained in Root's 'Dynamics of Engine and Shaft'."

Additional solutions will appear in the next number.

Locating That Gear Center

A veritable deluge of answers to J. A. Covington's problem on the location of the gear center, which appeared in the October number was received. All of the solutions were analytical, and most of them gave 8.93 in. for the gear radius, and 21.7 in. for the distance from the apex.

We must apologize for an overzealous editorial blue pencil which deleted the statement in Mr. Covington's problem that the "it" which caused the "sleepless nights" was a graphical layout that could be proved by geometry. This solution, which we have at hand, is extremely interesting and simple both in construction and proof, but we will first see what readers have to offer.

DEFLECTIONS

GENESIS OF CAR PRE-COOLING

According to Electric Refrigeration News, an old colored man who filled the ice-water coolers of the midnight Baltimore & Ohio train running from Baltimore to New York was responsible for giving the idea of pre-cooling trains to the B & O engineers. In the course of his duties one night, he chanced to leave a wagon-load of ice outside the window of one passenger who was sweltering in the summer heat. A slight breeze blew over the ice and cooled the passenger. The passenger reported his experience. Thus was started a series of experiments that resulted in the air-conditioned cars of today.

TWO-EYED TIMING CAMERA

At the crack of the starter's pistol at the recent Olympic Games, an electric impulse started a two-eyed motion-picture camera at the finish line. One of the eyes of the camera, developed by the Bell Laboratories, photographed the runners at the finish of each race, and the other recorded the exact time. The resulting strips of film show the runners crossing the line, and beside them the time accurate to a hundredth second.

THIS THING CALLED PROGRESS

After 40 years of making rivets, The Champion Rivet Co., Cleveland, Ohio, are announcing a new line of general-purpose welding rods. It should be added, however, that the company will continue its line of rivets.

NO TRICK AT ALL

John W. Kittredge, M.E., writes us quoting his brother, "It's no trick to be a salesman when you have something to sell that folks want to buy. When you have something to sell that folks don't want to buy, it's a H——l of a trick to be a salesman."

Cleveland Conference on Product Development

"Any company that does not keep up product development is riding for a fall . . . No matter how crazy an idea may seem, it may be the basis of an entirely new industry." Thus concluding his talk, Zay Jeffries, consulting metallurgist to the Aluminum Co. of America, expressed the thought which underlay all the talks given at a new product conference held Sept. 27-29 under the auspices of the Cleveland Engineering Society. Ten speakers participated in the four sessions of the conference, one session being devoted to research, one to development and marketing and two to products.

"Industry is so interrelated today," said Mr. Jeffries, "that any concern must be continually on the lookout for approaching signs of basic change . . . It is not enough that new products merely be improvements in bare mechanical performance. There must be increased eye-value . . . There must be better housings, better dress for all products." Mr. Jeffries warned manufacturers that they could go too far in making parts for their products. The more such a manufacturer relies on the specialized shop the more flexible his own organization becomes, and the better chance he has to adjust his own facilities to an ever-changing demand.

Frederick M. Feiker, director of Bureau of Foreign & Domestic Commerce, Washington, opened the conference formally with an address in which he discussed the present business situation. Mr. Feiker stated that it calls for imagination to apply the engineering, manufacturing and sales machinery of the country to the readjustment of business.

Eldridge Haynes, marketing counsellor, McGraw-Hill Publishing Co., suggested a marketing program for the manufacturer to bridge the gulf between the idea and profits from that idea. D. G. Smellie, director of development and design, Hoover Co., outlined the practical steps in product development. Gordon Armstrong, assistant to the president, Youngstown Pressed Steel Co., discussed "Marketing the New Product."

Bert Kent, patent attorney, Cleveland, outlined the rights of an employee to an idea which his employer patents and uses or sells. A. E. Buchenberg, vice-president in charge of engineering, Electric Auto-Lite Co., described the steps his company took in the design and manufacture of an electric clock. Floyd F. Kishline, assistant chief engineer, Graham-Paige Motor Co., set forth the factors that led to the design of the current Graham motor car.

N. R. Richardson, assistant works manager, Electric Controller & Manufacturing Co., emphasized the fact that in developing new products his company secured a great deal of important design data from the sales staff. Tell Berna, general sales manager, National Acme Co., explained the construction and use of the Chronolog, the newly developed electrical device for the control of idle production time.

The conference was attended by a representative group, including from one to six men each from 135 manufacturing establishments. The exhibits covered a wide field of industrial and consumer products.

National Business Show

Brand new developments in business office equipment vied with refinements at the 29th annual Business Show, which opened its week at the Grand Central Palace, New York, Oct. 17. Here was a duplicating machine making clear copies 14x20 in. at the rate of 5,000 per hour, there an electrically operated calculating machine doing multiplications, divisions, additions and subtractions at a speed 30 per cent faster than previous models. One hand operated calculating machine weighed but 6½ lb.

Probably the two most significant improvements for duplicating machines were an air device for "stripping" stencils from the printing drum without tearing or delay and a process whereby drawings are transferred to stencils by a photographic process.

One manufacturer featured a triple-head addressing machine, another a machine to print four original addresses on a power bill form. Still another printed an illustration and message on one side of a postcard and a name and address on the other at the rate of 60 per min. The designers of a manufacturer who has hitherto clung to movable type for his duplicating machines have turned to "dry" offset lithography from specially treated zinc sheets for at least one model.

Even more revolutionary is a machine, occupying less space than the average office desk, so connected to a standard typewriter that it casts lines of the matter being typed and slips them automatically into the drum of a standard office printing machine. The matrices for the type are on bars, longer but similar to the type bars used in certain adding machines. Pressing the typewriter key sets certain stops. By pressing a "casting key" the matrix bars are dropped to their appointed "stops," the type metal is poured, the bars return to place automatically.

Elaborate Test Program on Non-Ferrous Metals

Supported by many of the leading companies of the country, Committee B-3 of the American Society for Testing Materials is carrying out an elaborate and comprehensive test program for studying corrosion of non-ferrous metals and alloys. Over the past five years, during which extensive tests have been performed and preparations made for the unparalleled series of exposure tests now under way, it has been estimated that these companies have contributed more than $175,000 in the form of materials, special testing equipment, labor and funds.

In all, about 23,000 test specimens are being used in various phases of the work. Of these, 13,000 are in the form of standard tension test specimens, each carefully machined and finished. The remaining 10,000 are in various forms depending upon the type of test. The most extensive program is that sponsored by the subcommittee on atmospheric corrosion. These exposure tests will extend over a period of 25 years and will involve

the use of the greater part of the 23,000 specimens. Twenty-four different metals and alloys are being tested.

The amount of corrosion undergone by each metal and alloy is to be measured in two ways: by determining the change in weight of plate specimens; by determining the loss in strength and ductility by means of tension tests.

Exposed at each test location, of which there are nine in various sections of the country, there are four plate specimens of each material exposed, two designated as "removable," two as "permanent." Thirty tension test specimens of each material under test are also exposed at each test location. In addition, an extra set of 30 tension test specimens of each material was prepared and placed in air-tight glass containers and stored at the U. S. Bureau of Standards.

National Metal Congress

Attendance at the National Metal Congress and Exposition held at Buffalo, Oct. 3 to 7, by the American Society for Steel Treating with other engineering societies cooperating, was small but the quality was excellent. Principals can justify the expense of attendance, apparently, where assistants cannot. As a result contacts made were of the first order, and discussion at the engineering meetings was worth hearing.

Of the many interesting developments shown at the exposition two stood out: the application of the photo-electric cell to standard rivet and valve stem heaters by the American Car and Foundry Co.; and the use of the gas cutting flame for removing metal in a manner similar to the action of lathe and planer tools and milling cutters. At one of the engineering meetings the discussion led to a remark that die casting of steel is a not too distant possibility. Pressures of the order of 300,000 lb. per sq. in. will probably be employed.

Forty Billions Buying Power

A national questionnaire survey conducted among the employees of the Graybar Electric Co. in 73 leading cities of the country indicates the existence of a $40,000,000,000 latent consumer buying power in the United States at present. The survey was made, according to George E. Cullinan, vice-president of the company, to arrive at an accurate indicator in dollar volume of the pent-up demand now existing in this country for consumer goods, a demand which may be expected to be translated into actual orders with the return of public confidence in economic conditions.

To arrive at the sum total of existing consumer needs in this country at the present time, Graybar statisticians employed, for purposes of conservatism, a computing base of 18,000,000 families for the country, rather than the 30,000,000 recorded in the 1930 census.

The survey indicated that 1,110 Graybar employees will buy, when business conditions definitely improve and their incomes reflect this improvement, the following:

	Units	Per cent of all replies	Value	Approx. unit Value
New homes..	172	15½	$1,021,500	$6,000
Automobiles.	367	33	285,885	780
Refrigerators	491	44	85,211	175
Heating equipment.....	83	7½	21,700	262
Wash. Mach.	277	25	20,966	75
Radios.....	206	18½	14,067	70
Iron. mach...	155	14	13,192	85

Based on these figures, the total deferred demand in the United States, which will be purchased probably within the next two or three years as business conditions improve, includes the following:

	Units
New homes	3,096,000
Automobiles	6,006,000
Refrigerators	8,838,000
Heating equipment	1,494,000
Washing machines	4,986,000
Radios	3,708,000
Ironing machines	2,900,000

National Registration

At a recent meeting, the National Council of State Boards of Engineering Examiners gave formal approval to a system of national registration for engineers put into effect experimentally earlier in the year. Headquarters for the National Bureau of Engineering Registration have been established at Columbia, S. C., under the direction of T. Keith Legare, secretary of the council. The work of the bureau will be administered in conjunction with an advisory commitee appointed by the national engineering societies.

As pointed out by David B. Steinman, president of the council, the bureau was proposed as the start of a program for engineering, beginning with the student in the college and prescribing educational requirements. But, since a similar movement inaugurated by the A.S.M.E. has received the indorsement of the four major engineering societies, Dr. Steinman recommended that the council join the movement.

Meetings

A.S.M.E.

The National Wood Industries Meeting of the American Society of Mechanical Engineers will be held Nov. 15-16 at the Hotel Jamestown, Jamestown, N. Y., in cooperation with the National Furniture Manufacturers' Association. The program will consist of 14 technical papers presented in four sessions, a luncheon meeting and a plant inspection trip. Three papers are of particular interest to engineers and designers:

"Different Methods of Making Glue Joints"—G. M. Diehl.

"Modern Developments in Wood-Finishing Materials"—M. J. Pearce.

"Some Practical and Theoretical Considerations Involved in Laminating with Phenolic Resin"—E. H. Merritt.

The annual meeting of the American Society of Mechanical Engineers will be held Dec. 5-10, New York, N. Y. The program has not yet been announced.

Expositions

National Association of Practical Refrigerating Engineers — 23rd annual meeting and exposition of parts and equipment, Hotel Sherman, Chicago, Ill., Nov. 1-4.

Institute of Radio Engineers — Annual Meeting and Exposition, Sagamore Hotel, New York, N. Y., Nov. 7-9.

International Beverage Exposition, Public Auditorium, Cleveland, Ohio, Nov. 14-18.

Fourteenth Exposition of Chemical Industries, Grand Central Palace, New York, N. Y., Dec. 4-9.

National Exposition of Power & Mechanical Engineering, Grand Central Palace, New York, N. Y., Dec. 5-10.

Joint Trade Show, Motor & Equipment Manufacturers Association and National Standard Parts Association, Convention Hall, Detroit, Dec. 5-10.

National Automobile Show, Grand Central Palace, New York, N. Y., Jan. 7-14.

Engineers and their Activities

J. W. Barker

H. C. Dickinson

JOSEPH W. BARKER, dean of the faculty of engineering, Columbia University, has been elected president of the Illuminating Engineering Society.

DR. ERNST J. BERG, consulting engineer to the General Electric Co., has entered upon his duties as dean of the newly reorganized department of engineering, Union College, Schenectady, N. Y.

ALBEN F. CARLSON, who was chief body draftsman for the Pierce-Arrow Motor Car Co., Buffalo, N. Y. has resigned to enter the field of automotive sales.

W. B. COLEMAN, president, W. B. Coleman & Co., consulting metallurgists, is nominee for president of the American Society for Steel Treating.

J. M. CONNELLY has been promoted to the post of research engineer of the Kelvinator Corp., Detroit, Mich.

J. M. CRAWFORD, chief engineer, Chrevolet Motor Co., is nominee for vice-president of the S.A.E., representing passenger-car engineering.

Dr. H. C. DICKINSON, chief, heat and power division, Bureau of Standards, is nominee for president of the Society of Automotive Engineers.

ALEXIS S. GORSHKOFF has resigned as aeronautic engineer of the New Standard Aircraft Corp., Paterson, N. J. and is now located in New York, N. Y.

WILLIAM E. HERBY has resigned as acting chief engineer, Kinner Airplane & Motor Corp., and is temporarily in Springfield, Ohio.

HALL L. HIBBARD, formerly supervising engineer of Stearman-Varney, Inc., is now with Lockheed Aircraft Corp., Burbank, Calif.

CHARLES B. JAHNKE has been promoted from the position of engineer on internal combustion engines to that of research engineer of International Harvester Co., Chicago, Ill.

WALTER C. KEYS, consulting engineer, Detroit, Mich., has been elected to the council of the Society of Automotive Engineers to fill out the unexpired term of the late FRED S. DUESENBERG.

CLIFFORD J. LEISY has been promoted from project engineer to assistant chief engineer of the Great Lakes Aircraft Corp., Cleveland, Ohio.

EDWARD A. MALIN has resigned as vice-president in charge of engineering of the Pittsburgh Parts Corp., Pittsburgh, Pa.

WILLIAM B. MAYO, former executive engineer of Ford Motor Co., is working on the reorganization of Detroit Aircraft Corp.

F. P. MCKIBBEN, consulting engineer of the General Electric Co., has been awarded the Samuel Wylie Miller medal of the American Welding Society for outstanding contributions to the advancement of welding.

D. W. MCLENEGAN has been appointed assistant engineer of the commercial engineering division of the General Electric air-conditioning department.

W. E. RICHTER, JOHN DILOT, GILBERT E. WHITE, RUNO A. LEE and WALTER HARTJE, formerly members of the engineering staff of A. O. Smith Corp., have organized Meco, Inc., Milwaukee, Wis., for the development of inventions, general engineering and manufacturing service.

DELMAR G. ROOS, chief engineer of the Studebaker Corp., and vice-president of the S.A.E., is in Europe for the purpose of inspecting the latest offerings of the European automobile makers and conferring with their engineers.

H. L. VAN DOREN and J. G. RIDEOUT, chief designers for the Toledo Scale Co. and for Toledo Synthetic Products, Inc., have incorporated as Van Doren & Rideout, industrial designers, 2325 Madison Ave., Toledo, Ohio.

R. B. VOGT, formerly chief engineer of the Alvey-Ferguson Co., has taken up his duties as vice-president and chief engineer of the recently incorporated E. W. Buschman Co., Cincinnati, Ohio.

HERMAN A. WAGNER, consulting engineer, was awarded the Clausen gold medal at the annual meeting of the American Association of Engineers for distinguished work in promoting the economic welfare of the engineer.

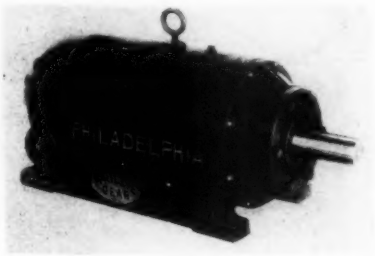
NATHANIEL B. WALES, inventor of the Kelvinator refrigerator, is now associated with G. M. Basford Co., New York, industrial marketing counselors, in the new products development division in charge of engineering and research.

A. V. D. WILLGOOS, chief engineer, Pratt & Whitney Aircraft Co., is nominee for vice-president of the Society of Automotive Engineers representing aircraft-engine engineering.

NEW MATERIALS AND PARTS

Philadelphia Motoreducers

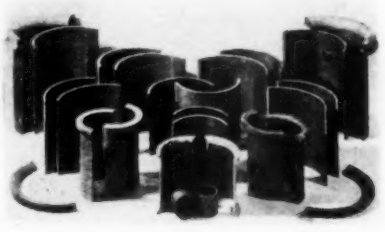
Called "MotoReduceR" by the manufacturer. Motor and gear apparatus contained in single housing with supporting feet at each end of frame. No overhang of gear or motor. Heat-treated nickel-steel helical gears run in oil bath. All bearings of anti-friction type, the slow-speed shaft being mounted on oversize Timken roller bearings so spaced as to permit overhang of pinion, sprocket or pulley without outboard bearing support.



Available in single, double and triple types with ratios up to 450 to 1. Furnished with standard open type or totally inclosed fan-cooled motors, polyphase and single phase. Also available with d.c. motors up to 10 hp. Philadelphia Gear Works, Erie Ave. at G St., Philadelphia, Pa.

"Ryertex" Bearings

Molded at pressure of approximately 2,000 lb. per sq.in., and at temperature of 340 deg. F. A synthetic resinoid similar to Bakelite, reinforced with textile material of belting quality and strength. Characteristics listed by the manufacturer:



cannot be re-softened by heat; will not absorb water or oil; resistant to most acids, but attacked by hot caustic alkalies; Brinell hardness 30-40, Scleroscope 70-80; particularly satisfactory in cases where it is easier to apply water as a lubricant than oil though they operate satisfactorily with oil. Claimed to outlast babbitt and bronze applications. Joseph T. Ryerson & Son, Inc., 16th & Rockwell St., Chicago, Ill.

Continental-Diamond Dilecto Uf

Is a new laminated synthetic resinous material, combined with either paper or fabric. Available in sheets, tubes or rods, colored in any translucent or opaque shade, and with glossy finish. Surface can be sanded. Fabricated by cutting or machining. Up to and including $\frac{1}{16}$ in. thick, it can be punched hot with a preheating temperature not in excess of 120 deg. C.

Tests conducted on $\frac{1}{16}$-in. specimens gave folowing results:

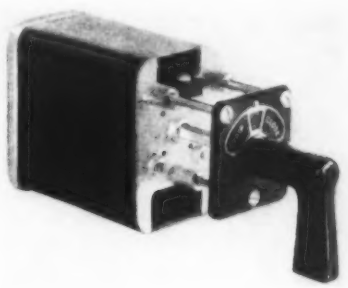
Specific gravity	1.45 to 1.49
Tensile strength, lb. per sq.in.	8,500 to 9,322
Flexual strength, lb. per sq.in.	16,800 to 24,082
Hardness (Brinell)	32.5 to 39
Water absorption, 24 hr.	1 to 2 per cent
Dielectric strength, volts per mil.	482 to 600
Dielectric constant, 500 kilocycles	6.5 to 7.45
Power factor, 500 kilocycles	2.88 to 369
Loss factor	18.7 to 27.5

Material resists surface attacks from common reagents, such as cold, dilute acids and alkalis. This includes soap solutions and fruit acids, but not hot concentrated acids nor lye. Unaffected by common solvents, such as alcohol, acetone, benzol, carbon tetrachloride, oil and carbon bisulphide. Not flammable; does not support combustion. Suggested applications: electrical appliances; indicator dials; switchboard installations; molded containers, and as glass substitute. The Continental-Diamond Fibre Co., Newark, Del.

General Electric SB-1 Switch

Designed to operate circuit breakers, governors, rheostats, instrument transfer, and the like. Various combinations for different applications are made up of interchangeable parts, combinations differing only in number of contacts and arrangement of operating cams. Escutcheon plate markings and handle styles differ for various applications. Breaker control type available with auxiliary contacts to operate in connection with a dim-bright indicating lamp scheme.

Features listed by manufacturer: positive silver-to-silver contacts; all connections fastened by screwdriver; ample room for connecting leads; colored mechanical target to indicate last operation of breaker control switch; small panel space required;



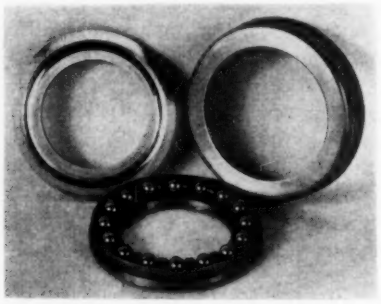
Textolite escutcheon plate. Rating: 600 volt, 10 amp. continuous, or 250 amp. for 3 seconds. General Electric Co., Schenectady, N. Y.

Swiv-all Plug

With swivel feature to eliminate twisted or kinked appliance cords. Made in three parts assembled as a unit. Part to which cord is attached responds to turning of cord. Phosphor bronze contacting members. Black or brown Bakelite. Swiv-all Products Corp., Bridgeport, Conn.

Bantam Ball Thrust Bearing

Designed for clutch throw out or clutch release application. Cast bronze retainer. Special grease retaining band extends down past center line of balls so that centrifugal force tends to hold grease within bearing instead of throwing it out. With this



construction the manufacturer claims it is possible to remove all oil tubes and grease fittings as in clutch pilot bearing practice. The Bantam Ball Bearing Co., South Bend, Ind.

Tuthill Standard Pump Parts

Consisting of standard cover, idler pin, idler and rotor of rotary pump for incorporaton into design of practically any machine using pump for lubricating oil or coolant. All bores circular and concentric to permit machining of housing or packing box on an engine lathe at a single setting. Designing engineer permitted almost any combination of port arrangements with assurance of compact pumping unit. Accompanying isometric diagrams show parts furnished and machining necessary to receive these parts. To avoid confusion, port arrangements shown only in three top views: *A, B* and *C*. Intake and discharge ports, represented by "in" and "out," will interchange when direction of shaft rotation is reversed. Counter-clockwise rotation, facing shaft end of pump, shown in these diagrams. Tuthill Pump Co., 131 W. 63rd St., Chicago, Ill.

"Rust-Tox"

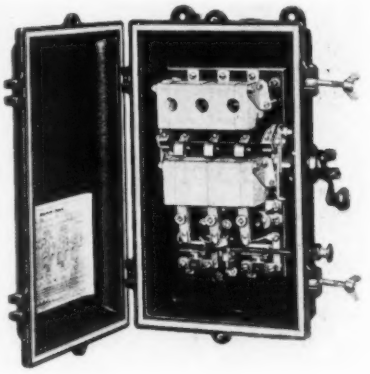
A colorless, transparent, rust inhibitor, sealer or under-coat. Claimed capable of resisting heat up to 550 deg. F., acid fumes, smoke, salt air and oxygen. Can be sprayed or brushed at any temperature above 35 deg. F. "Bakes on" under rivet heads in plate joints to leave water and air-tight coating. Can be used as vehicle for aluminum flakes, red lead or graphite. The Skybryte Co., 1919 E. 19th St., Cleveland, Ohio.

Houghton No. 2 Metal Primer

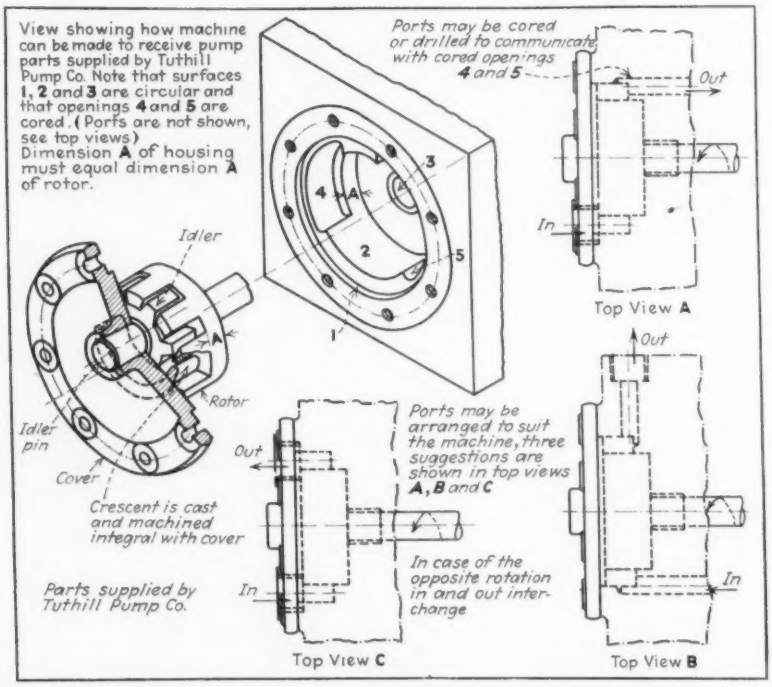
For application as an undercoat to structural steel. Compounded of sublimed blue lead and special type of vehicle or binder. Advantages listed by producer: two to two and one-half times covering capacity of red lead and oil; tougher, harder and more tenacious coating; will not chalk off after many months exposure to atmosphere; effective rust inhibitor. E. F. Houghton & Co., Philadelphia, Pa.

"Square D" A.C. Combination Starters

Of water and dust-tight construction in cast-iron type. Intended for installation on machinery in damp or dusty locations and corrosive atmospheres. Not explosion proof. Unit consists of across-the-line starter, motor control switch and test jack. Thermal overload and low-voltage protection. Cast-iron cabinet having

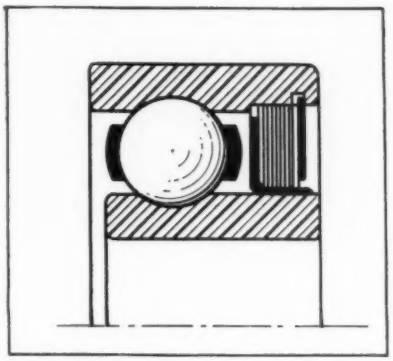


machined flanges fitted with rubber gaskets. Two sizes: Class 8532S and 8536S, furnished fusible or non-fusible. Industrial Controller Division, Square D Co., Milwaukee, Wis.


View showing how machine can be made to receive pump parts supplied by Tuthill Pump Co. Note that surfaces 1, 2 and 3 are circular and that openings 4 and 5 are cored. (Ports are not shown, see top views) Dimension A of housing must equal dimension A of rotor.
Ports may be cored or drilled to communicate with cored openings 4 and 5
Out
In
Top View A
Idler
Rotor
Idler pin
Cover
Crescent is cast and machined integral with cover
Parts supplied by Tuthill Pump Co.
Ports may be arranged to suit the machine, three suggestions are shown in top views A, B and C
In case of the opposite rotation in and out interchange
Top View C
Top View B

Fafnir "T" Type Felt-Seal Bearing

Does away with pressed steel shell formerly fitted over one face of bearing. Felt seal is inside of and located by outer ring. By extending width of both inner and outer ring on one side of ball race, space is provided for fitting entire seal assembly between the two rings. A steel slinger is first pressed on the inner ring, woven felt washer placed next to it and held in position by a spring retaining washer fitted into slight groove on inside of outer ring. Oil-proof paper washer is slipped in between felt and retaining washer to seal opening in latter. Steel slinger rotates with inner ring, while felt washer revolves with outer ring, pro-

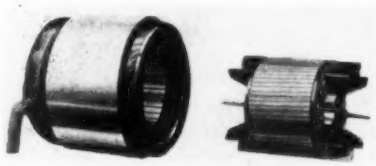


viding baffling effect which adds to efficiency. Manufacturer claims much more standard closure and more effective sealing as result.

Available in popular sizes of the extra small 30 series, the light 200 series, and the medium 300 series. Since same over-all widths prevail as in previous felt-seal design, T-type bearings can be substituted for J-type. The Fafnir Bearing Co., New Britain, Conn.

Allis Rapid-Reversing Motors

Of the squirrel-cage type designed to reverse 60 times per minute continuously without overheating. Features listed by the manufacturer include: light-weight rotor construction; efficient ventilation; high-torque characteristics; cast-iron frames. Adapted to practically all machines that utilize fast reciprocating or reversing motions, or frequent starting and stopping. Available in standard



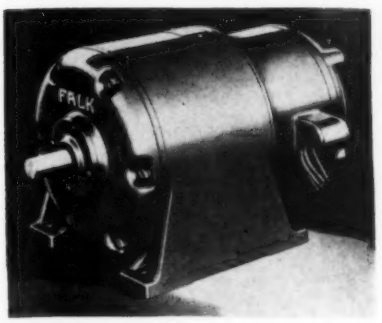
open ball-bearing type or rolled-shell shaftless type, as shown in the accompanying illustration; also in vertical, single-speed, multi-speed, inclosed fan-cooled, and other squirrel-cage types. No auxiliary ventilation needed in sizes up to 5 hp. The Louis Allis Co., Milwaukee, Wis.

"Cassvell" Vellum Tracing Paper

The manufacturer lists the following characteristics: white; odorless; dry surface—will not transfer oil; will not yellow; tracing cloth pounce unnecessary; permanent transparency; good erasing qualities due to dry surface. Cassvell vellum No. 102 available in 20-yd. rolls, 36 in. wide, or 42 in. wide. National Consumers Paper Corp., Technical Papers Division, 227 Sixth Ave., New York, N. Y.

Falk Motoreducers

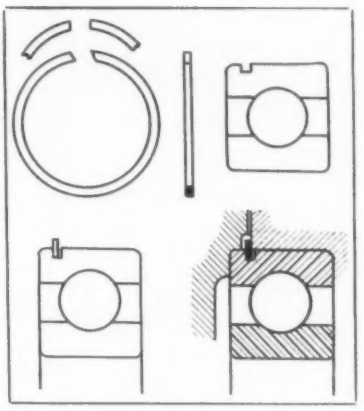
In three styles of combined motor and speed reducer: "integral type"—motor end bell removed and motor frame close coupled through bayonet-type joint to gear case; "flexible type"—round frame type of motor with end bell retained; "all-motor type"—for any standard horizontal



type motor, connected through a Falk flexible coupling to reducer housing. Integral-type motoreducer illustrated. In all three styles, gear housing acts as support for motor. Non-planetary, helical-type gearing. Ball bearings in all but larger sizes. Efficiency claimed to be minimum of 97 per cent. All types supplied in horsepowers from $\frac{3}{4}$ to 75, with ratios from 4.6 to 288. The Falk Corp., Milwaukee, Wis.

Marlin-Rockwell "G" Type Ball Bearings

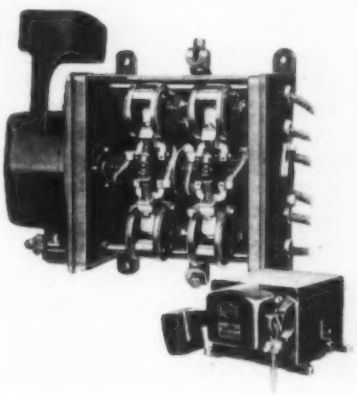
Consists essentially of standard single-row bearings with a groove cut into outside of outer race, hence the name "G" type. This groove accommodates snap ring which functions to take thrust in one direction, thus eliminating need for shoulder against one side of outer race. First developed for quantity use in automobile transmissions, the G-type provides advantages of a through bore in a mounting. Snap ring itself will not carry thrust in both directions because groove is turned and ring must fit in it loosely. Where looseness becomes too great, paper gasket used



for a lubricant seal can be used in duplicate. G-type can be combined with shielded or lubri-seal type. Sizes available: most of the intermediate sizes in the light and medium series bearings. Marlin-Rockwell Corp., Jamestown, N. Y.

Cutler-Hammer Limit Stop

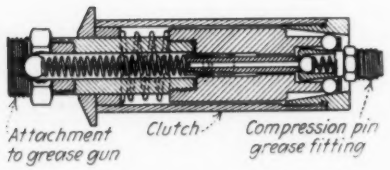
In new small-size with standard mill-type blowouts and contact tips. These stops designed especially to prevent over-travel of the hoist on electric cranes. Supplied complete with leads equipped with soldering lugs. Cover removable for inspection



and repairs. Limit stop takes only 9-in. headroom. Rated for 40 hp. and under. Cutler-Hammer, Inc., 12th & St. Paul Ave., Milwaukee, Wis.

A. B. C. Greasing System

Consists of a patented clutch to be attached to a screw-type, push-type or heavy-duty greasing gun and a compression pin grease fitting. A plunger first actuated by spring and later by pressure of grease applied seals compression pin so that no



grease can escape. With ball and wedge design, it is claimed that the greater the pressure of the grease applied the tighter the sealing of the compression pin. Available in two sizes; lighter model for hand-operated guns; heavier model for power system. The Bridge Tool & Mfg. Co., 779 Bryant St., San Francisco, Calif.

New Books and Publications

"Applied Gyrodynamics"

Ervin S. Ferry, professor of physics, Purdue University. 272 pages, 5¾x9 in. Clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $4.

Gyrodynamics is usually "hedged about by a wall of differential equation," as stated by the author in his preface. But in this book he has succeeded to a remarkable degree in accomplishing his expressed purpose of bringing the subject "from behind the integral sign and to present it to the acquaintance of engineers and students having the mathematical equipment of the ordinary graduate of engineering or physics."

There are several factors that undoubtedly contribute most to the value of this book. First, the author starts with a chapter on definitions and principles of elementary dynamics, thus establishing a sound working basis for the reader. Second, descriptions of experiments are resorted to, and the physical concepts are carefully developed before the mathematical equations are presented. Finally, the numerous practical applications of the gyroscope and gyro principles are gone into, with illustrations and descriptions.

"House Design, Construction and Equipment"

Edited by John M. Gries and James Ford. 313 pages, 6x9 in. Clothboard covers. Issued by the President's Conference on Home Building and Home Ownership. Price $1.15 (Checks should be made payable to John M. Gries, executive secretary, New Commerce Building, Washington, D. C.)

Everyone should be interested in home building. Engineers and production men will, in addition, find special interest in the portions of this book recommending "manufactured" construction, labor saving tools, and improved construction methods. Of course, the book has all the ear marks of a committee publication and the wealth of information given could be put in greatly condensed form.

Aluminum

Aluminum Co. of America, Pittsburgh, Pa. A supplement to the "Structural Aluminum Handbook" lists corrections in the original edition and provides additional engineering data.

Clutches

Ramsey Chain Co., Inc., Albany, N. Y. Bulletin 632 provides full data on the Ramsey-Pulvis clutch.

Electrical Equipment

Crouse-Hinds Co., Syracuse, N. Y. Bulletin 2254 (second edition) "Explosion-Proof Condulets for Hazardous Locations" also lists explosion-proof switches, circuit breakers and the like.

Expansion Joints

Fulton Sylphon Co., Knoxville, Tenn. Temporary Bulletin No. 800 provides data on the "Sylphon Packless Expansion Joint No. 111."

Gears

Gleason Works, 1000 University Ave., Rochester, N. Y. "Engineering Data on Large Hypoid and Spiral Bevel Gears." Form No. 600, also includes drawings of typical mountings.

Hard Rubber

The B. F. Goodrich Rubber Co., Akron, Ohio. Booklet No. 9405 presents new information on hard rubber in sheet, rod and tubing form.

Motors

General Electric Co., Schenectady, N. Y. Bulletin GEA-1366 presents data on Type KR, totally inclosed, small a.c. hoist motors.

Plugs and Connectors

Belden Mfg. Co., 4689 W. Van Buren St., Chicago, Ill. Bulletin No. 4714 describes a complete line of soft rubber plugs, sockets and connectors.

Product Appearance

The Public Library and The Museum, Newark, N. J. Published jointly, "Design in Industry" begins its third volume of 10 numbers each. This publication attempts to annotate all the current books, pamphlets and articles in periodicals on the subject. Free to residents of Newark, N. J. Price to non-residents, $2.00 per annum.

Taylor System, Inc., 285 Madison Ave., New York, N. Y. "Making the Sphinx Talk" describes a service for manufacturers which includes the development of new products and the creation of new designs and colors.

Relays

Hart Mfg .Co., Hartford, Conn. A new four-page folder describes the "Diamond H" magnetrole relay.

Rubber Paint

The B. F. Goodrich Rubber Co., Akron, Ohio. Sales Manual Section No. 9660 describes "Acidseal" rubber-base paint.

Speed Reducers

The Falk Corp., Milwaukee, Wis. Bulletin No. 260 entitled "Falk Motoreducers" gives full details of a new line combining standard makes of motors with Falk speed reducers.

Winfield H. Smith, Inc., Springville, Erie County, N. Y. Catalog No. 27 classifies the full line of "WHS" speed reducers and transmission machinery.

Squirrel-Cage Motors

General Electric Co., Schenectady, N. Y. Publication No. GEA-1628 describes and illustrates squirrel-cage motors and controls. It lists the numbers of the publication describing particular models.

Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Publication L. 20386-A describes the application and distinctive features of Linestart Type CS squirrel-cage induction motors.

Steel Tube

The Carpenter Steel Co., 100 Broadway, New York, N. Y. "Carpenter Stainless Welded Tube" lists shapes and sizes available and gives physical characteristics.

Tensometers

Baldwin-Southwark Corp., Southwark Division, Philadelphia, Pa. Bulletin No. 37 covers the line of lever-type strain gages known as Huggenberger tensometers and discusses the fundamental principles of these instruments. Bulletin No. 40 gives full details on "The Scratch Extensometer."

Thermostats

Minneapolis-Honeywell Regulator Co., Minneapolis, Minn. New loose-leaf catalog pages No. M5, T414 and T9 have as their subjects: "Electric Clock Thermostat," "Refrigeration Temperature Control (Remote Type)" and "The Modutrol" system of temperature control.

Thrust Bearings

Kingsbury Machine Works, Inc., 4324 Tackawana St., Philadelphia Pa. Bulletin "S" illustrates and describes horizontal mountings for thrust bearings and journal bearings, small to medium sizes.

Round-Wire Springs

Contributed by Victor Tatarinoff

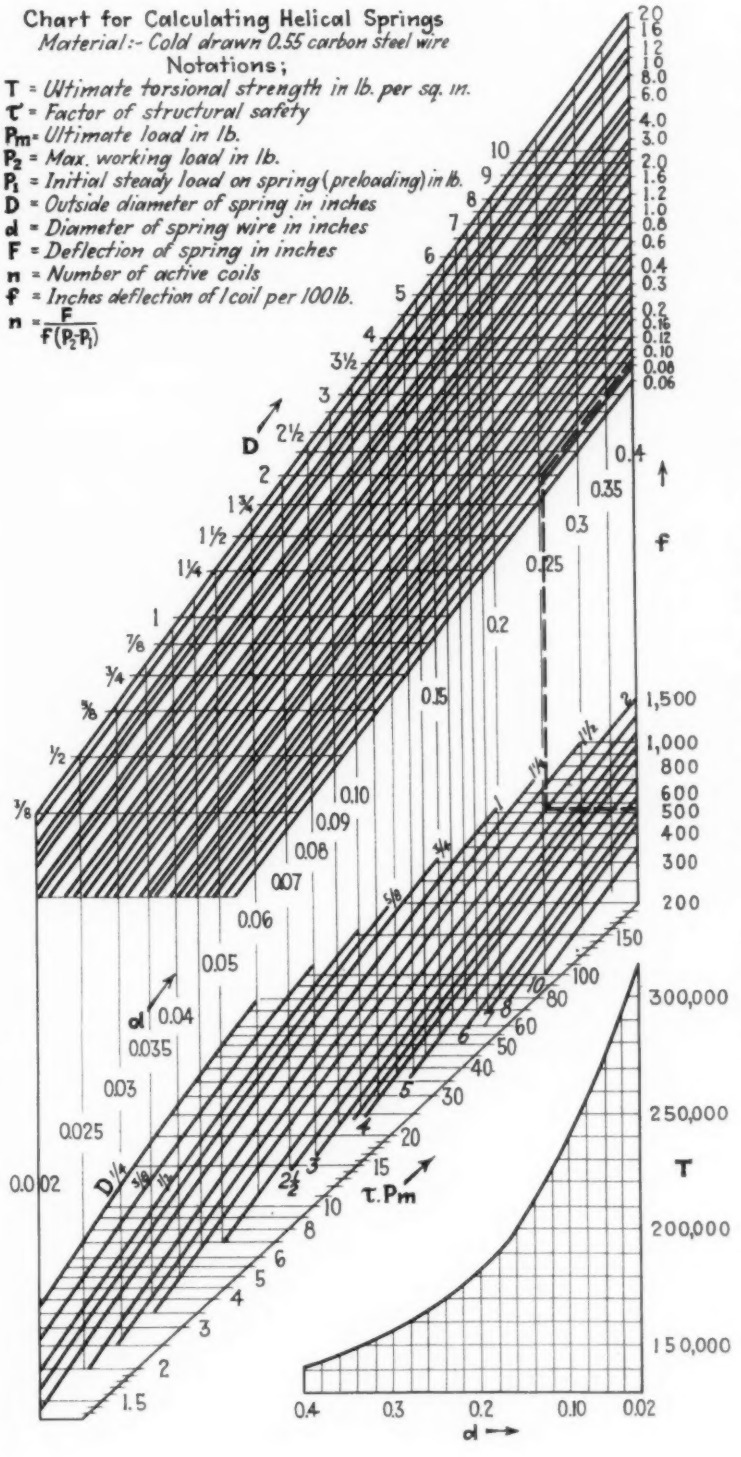


Chart for Calculating Helical Springs
Material:- Cold drawn 0.55 carbon steel wire
Notations;
T = Ultimate torsional strength in lb. per sq. in.
τ = Factor of structural safety
Pm = Ultimate load in lb.
P2 = Max. working load in lb.
P1 = Initial steady load on spring (preloading) in lb.
D = Outside diameter of spring in inches
d = Diameter of spring wire in inches
F = Deflection of spring in inches
n = Number of active coils
f = Inches deflection of 1 coil per 100 lb.
n = F / f(P2-P1)
D
d
f
T
τ.Pm

The deflection formula for round-wire springs, may be written:

$$\frac{F}{n(P_2 - P_1)} = \frac{8\left[(D-d)^3 + 0.5d^2(D-d)\right]}{Gd^4} = \frac{f}{100}$$

G is the modulus of elasticity in shear, all other symbols being as given on the chart.

The number of inactive coils, m is based upon the number of active coils. For compression springs of less than 5 active turns or coils, $m = 1.5$; for 5 to 10 active turns, $m = 2.0$; for more turns $m = 2.5$.

To the left, the lower graph refers to cold-drawn untempered steel wire for 0.02 to 0.4 in. diameter. The ultimate strength of the material in torsion is given by the curve in the lower right corner.

If τP_m and D are given, intersection of corresponding sloping and horizontal lines in the lower chart, gives the wire diameter in inches as read on the d scale. Going vertically into the upper chart to the horizontal line indicating the outside diameter of the spring, the corresponding diagonal line gives deflection per active coil per 100 lb.

As an example, assume a 2 in. outside diameter spring of cold-drawn steel wire. Initial load P_1 to be 145 lb., maximum final load P_2 to be 164 lb. Compression of spring, F, to be 0.375 in., $\tau = 3$. Assume $P_m = 1.05\ P_2 = 172$ lb.

$$\tau P_m = 3 \times 172 = 516 \text{ lb.}$$

To obtain wire diameter, trace horizontally from 516 on vertical scale, as shown by dotted line, to sloping line representing $D = 2$ in. giving $d = 0.254$. Tracing upward to the horizontal line $D = 2$ in., and following along the sloping line, gives $f = 0.088$ per 100 lb.

$$n = \frac{100F}{f\ (P_2 - P_1)} = 22.5$$

$m = 2.5$

L_1 (initial length of spring)

$$= (n + m - 0.5)\ d + \frac{P_2 - P_1}{P_m - P_1} F$$

$$= 6.75 \text{ in.}$$

L_0 (free length)

$$= L_1 + \frac{P_2 - P_1}{P_1} F$$

$$= 6.75 + \frac{164 - 145}{145} \times 0.375 = 9.6 \text{ in.}$$

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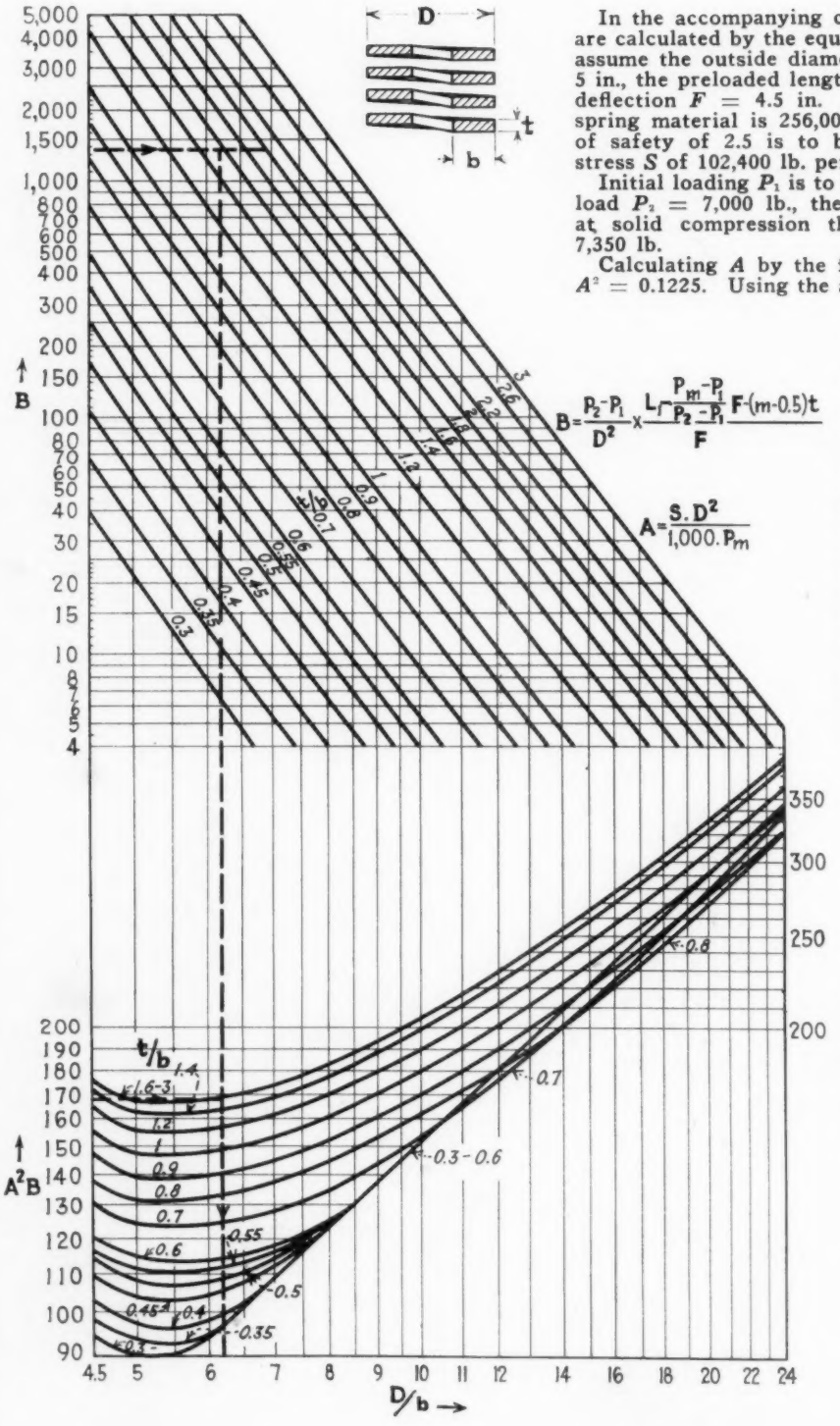
Rectangular-Wire Springs



In the accompanying charts the values of A and B are calculated by the equations given. As an example, assume the outside diameter D of the spring is to be 5 in., the preloaded length $L_1 = 29.5$ in., and the total deflection $F = 4.5$ in. Ultimate strength T of the spring material is 256,000 lb. per sq.in., and a factor of safety of 2.5 is to be used, giving an allowable stress S of 102,400 lb. per sq.in.

Initial loading P_1 is to be 550 lb., and maximum final load $P_2 = 7{,}000$ lb., the ultimate maximum load P_m at solid compression then being $1.05 \times 7{,}000 = 7{,}350$ lb.

Calculating A by the formula given, $A = 0.35$ and $A^2 = 0.1225$. Using the approximate formula:

$$B = \frac{P_2 - P_1}{D^2} \times \frac{L_1 - 1.25\,F}{F}$$

$B = 1{,}370 \quad A^2B = 168$

Assuming a trial value of 1.8 for t/b, starting at $A^2B = 168$, then to the right to the sloping line $t/b = 1.4$, vertically upward to the horizontal line $B = 1{,}370$, we come to the sloping line $t/b = 1.9$. As this value does not correspond to the value chosen initially, another estimate of t/b must be made.

Selecting $t/b = 1.54$ and repeating, coinciding values of t/b are obtained, and a value of $D/b = 6.2$, whence $b = 0.807$, $t = 1.54b = 1.24$.

Using the values given:

$$\frac{P_m - P_1}{P_2 - P_1} \quad F = 4.73$$

$$m = 2$$

$$t\,(max) = 0.48\,t \quad \frac{2D - b}{D - b}$$

$$= 1.30 \text{ in.}$$

Here t (max) is the maximum thickness at the inner side resulting from the rectangular wire taking a trapezoidal shape. Recalculating B using t (max) in place of t, $B = 1{,}245$, $A^2B = 153$. The procedure as above is repeated, until complete agreement is gotten whence:

$t/b = 1.1 \quad D/b = 5.3, \quad b = 0.96$

$t = 1.06, \; t\,(max) = 1.14$

Number of coils n, will then be

$$n = \frac{L_1 - \frac{P_m - P_1}{P - P_1} F - (m - 0.5)\,t}{t}$$

$$= 20.5$$

Free length L_0 will be

$$L_0 = L_1 \frac{P_1}{P_2 - P_1} F = 30 \text{ in.}$$

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